2005

Ergonomic product intervention and training on productivity and comfort

Dawn Armstrong Langer
San Jose State University

ERGONOMIC PRODUCT INTERVENTION AND TRAINING ON PRODUCTIVITY AND COMFORT

A Thesis

Presented to

The Faculty of the Program of Human Factors and Ergonomics

San José State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Dawn Armstrong Langer

December 2005

UMI Number: 1436926

APPROVED FOR THE GRADUATE
PROGRAM IN
HUMAN FACTORS / ERGONOMICS

Dr. Emily H. Wughalter, Chair
Professor, Department of Kinesiology

Dr. Kevin M. Corker, Member
Professor, Department of Industrial & Systems Engineering

Dr. David M. Furst, Member
Department of Kinesiology

APPROVED FOR THE UNIVERSITY

ABSTRACT

ERGONOMIC PRODUCT INTERVENTION AND TRAINING ON PRODUCTIVITY AND COMFORT

By Dawn Armstrong Langer

The effects of ergonomic product intervention and training on productivity were examined in the present study. Remedy Interactive's RSIGuard 3.0 software program was used to measure productivity for 30 participants over 120 days. Comfort was measured via a customized online weekly questionnaire. One half (n=14) of participants were trained. Productivity was significantly affected by a combination of product installation, instructor training, and web based training. Best productivity results were found within 2-week intervals. Mean productivity was higher for trained versus untrained groups. Comfort results showed a 70% decrease in frequency of pre versus post study discomfort responses, and a 57 to 87% decrease in frequency of discomfort responses related to each of 11 body parts.

DEDICATION

The present study is dedicated to the important men in my life: my birth father, my adoptive father, my sweetheart, my brother, and my grandfathers. Some have been with me in spirit, others have been with me in person; all will be very proud of me at the completion of this document. The present study is also dedicated to the important women in my life: my mother, grandmothers, and good friends; all supported me through each and every draft and due date. Last, but not least, the present study is dedicated to the angels who answer every fervent prayer I have had along the journey.

ACKNOWLEDGMENTS

The present study was an interesting experience in flexibility, strategic partnering, and the principles of Toyota's Plan Do Check Action (PDCA) project management techniques. Key contributions to the study came from many areas including: Dr. Ronald Rogers from San José State University (SJSU) and Dr. Alan Hedge from Cornell University (Cornell) who helped design the study; my good friend and colleague Mary Fe Cadiente who supported me throughout my data analysis and every phase following; and participants at the University of California, Santa Barbara (UCSB). The present study was funded by private industry research grants provided by Remedy Interactive, Inc. (formerly known as Workwell, Inc.), Kensington Ergonomic Products, Inc., Humanscale Corporation, Proactive Ergonomics, and Elysian Integrated Health Solutions (formerly known as Total Body Ergonomics). Special thanks to my advisor, Dr. Emily Wughalter, and to my committee members, Dr. Kevin Corker and Dr. David Furst, for their expertise, support, and confidence in my efforts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

Introduction

Over the last several years, manufacturers have made great strides in ergonomic product design. For many years computer users had only the standard personal computer equipment available to them. The last decade provided users a variety of tools with which they could interface including alternatively designed keyboard trays, keyboards, and input devices. Reduced budgets and staffing are incentives for companies to rely on ergonomic product design to lower work related ergonomic injury costs; which raises the question, What impact does ergonomic product training have on productivity and comfort? In 2003, 4.4 million non fatal injuries and illnesses were reported in private workplaces. Sprains and strains were the leading injury or illness in every major industry sector (Bureau of Labor Statistics [BLS], 2003). In 2001, employers reported a total of 1.5 million lost work days due to work related injuries and illnesses, nearly 50% of which were due to musculoskeletal disorders (Journal of American Medical Association [JAMA], 2003). With over 70 million people using computers at work (OSHA, 2000), companies are increasingly relying on ergonomic products to reduce discomfort. The following questions need to be addressed: What is the learning curve on a new product; How does the learning curve affect productivity and comfort; and, Will ergonomic software training have the same impact as in-person training? The present study was designed to address the questions above and to contribute to the body of ergonomic knowledge.

Risks of Buying/Using Misrepresentative Products

Over the last decade the boom in personal computer accessories brought opportunity for increased comfort as well as for increased frequency of injury. Often employees or companies order ergonomic products in an effort to reduce upper extremity discomfort while computing (Nelson & Silverstein, 1998; Stevens, Witt, Smith, & Weaver, 2001). Whereas a well-designed ergonomic product can decrease discomfort and increase productivity due to a reduction in physical demand required while performing a task, if an ergonomic product has not been designed by a human factors usability engineer negative effects may occur (Zecevic, Miller, & Harburn, 2000). In addition, if the employee has not been trained on the features and use of a new tool design, productivity may decrease (Swanson, Galinsky, Cole, Pan, & Sauter, 1997). It is essential for organizations to take responsibility for ensuring usability testing on employee interface products, and that user interface has a large effect on usability of the product (Hix, D., & Harston, H.R., 1993). In California alone, 42% of occupational carpal tunnel syndrome cases occur in conjunction with keyboard use (California Department of Health Services [CDHS], 2000). Research indicated that moderate user training combined with flexible product deployment is best for counteracting new tool productivity declines (Swanson et al., 1997; Zecevic et al., 2000).

Many manufacturers liberally use the term ergonomic as a marketing ploy to increase sales and dupe users into buying products that have not been usability tested using the expertise of human factors engineers. Furniture, facilities, electronic, and ergonomic trade shows occur annually throughout the United States providing innovative companies and charlatans the opportunity to promote their products on untrained ergonomic program managers. One of the dangers of promoting office ergonomic products at furniture and facilities tradeshows is having facilities, real estate, and planning managers making decisions on office ergonomic products which may result in decreased employee productivity and increased company costs (Govindaraju, Pennathur, & Mital, 2001). Productivity is often decreased by employee discomfort and lack of product training. Company costs are often increased due to frequent equipment replacement, lost workdays, legal action suits, and high workers compensation premiums (OSHA, 2000). In 2003, 1.3 billion work injuries required more than 1 day from work, with carpal tunnel syndrome having a median lost work day number of 38 (Bureau of Labor Statistics [BLS], 2003). In 2001, over 80 billion dollars were spent on direct (20 billion) and indirect (60 billion) worker's compensation costs (JAMA, 2003). In 2000, over 50 billion dollars were spent nationwide on direct and indirect costs related to workplace musculoskeletal injury (Occupational Safety and Health Administration [OSHA], 2000).

Importance of Product Training

One question addressed in the present study was, What impact does ergonomic product training have on comfort and productivity? Without the benefit of in-person instructor training, employees must rely on product instruction manuals to install and use new ergonomic equipment. Reasons that instruction manuals may not be as effective as in-person instructor training include: 1) variation in instructional ease for individual manuals; 2) procrastination as a deterrent to reading manual; 3) busy work schedules interfering with product familiarization time; and 4) lack of knowledgeable personnel (ergonomists) to provide training in the workplace. Secondary questions the present study addressed included: Can ergonomic web based training replace in-person instructor training; How necessary is training for new ergonomic products; and, What is the learning curve on a new product?

Recent research has found that the introduction of new product designs in the workplace often result in a decrease in user productivity due to a steep initial learning curve with a new product (Zecevic et al., 2000). Studies have found, when a user receives a new interface tool there is an initial decrease in productivity ranging from hours to days, with a resulting productivity increase as the user gains product use experience (Karlvist, L., Hagbert, M., & Selin, K., 1994; Swanson et al., 1997). In addition, the most ergonomically designed product may also cause increased employee discomfort and risk of injury if proper training and adjustment of the product have not occurred (Zecevik et al., 2000). Examples of ergonomic interventions that lead to potential initial decreases in productivity due to the use of ergonomic products include using a new keyboard tray, ergonomic keyboard, or web based training program as replacements for the standard issue work surface, keyboard, and in-person instructor training.

While several studies have been done on ergonomic postures, wrist and forearm range of motion, and employee discomfort levels in relation to ergonomic keyboard design (Hallbeck, M.S., 1994; Hedge and Morimoto, 1999; Marshall, Mozrall, & Shealy, 1999; Sauter & Scliefer, 1991; Serina, Tal, & Rempel, 1999; Simoneau, Marklin &

Monroe, 1999), and other studies have looked at keyboard design in relationship to discomfort and performance (Hedge & Powers, 1995; Muss, T., & Hedge, A., 1999; Oates, S., Evans, G., & Hedge, A., 1998; Smith, Karsh, Conway, & Cohen, et al., 1998), few experiments have looked at how training affects the productivity curve related to introduction of a new ergonomic product in the workplace (Karlvist et al., 1997; Swanson et al, 1997).

Problem Statement

The recent boom in ergonomic product availability has increased personal computer accessory choices and reduced discomfort, but new product designs require training and experience to reap productivity benefits. The steep learning curve associated with using an unfamiliar product initially decreases productivity. The present study investigated the effects of ergonomic product intervention and training on employee productivity and comfort.

Null Hypotheses

The following null hypotheses were made for the study:

1. Ergonomic product intervention will not affect productivity and discomfort
2. Training will not affect productivity and discomfort.
3. Ergonomic product intervention and training will not interact to affect productivity and discomfort.

Limitations

The present study was a field study maximizing representation while increasing generalizability to operational settings (Vicente, 1997). Vicente (1997, p.324) discussed the benefits of a field study in that it helps to increase the ecological validity of experimental research. In the present study participants worked in an office setting with similar job tasks, working conditions, and equipment which reduced confounding variables related to same. In an effort to limit confounding effects of participant drop out, and to maximize probability of an equal distribution of males and females in the groups, 100 employees were initially recruited to volunteer. Only 50 participants met the requirements set in the delimitations and the final sample consisted of 30 participants.

Delimitations

The present study was delimited to an asymptomatic population available on the day shift over the duration of a 120-day study. To reduce the effect of experience as a confounding variable, the present study was delimited to employees who were currently using workstations without ergonomic interventions, and who had no previous formal training on keyboard trays, ergonomic keyboards, and ergonomic web based training. In an effort to reduce the effect of discomfort level as a confounding variable within groups, discomfort was tracked individually over time using participant responses to an online discomfort questionnaire. Participants did not have prior formal experience with ergonomic keyboard trays or ergonomic keyboards, but had full knowledge of the purpose of the experiment. In an effort to reduce confounding factors related to feelings of scarcity or unfair treatment, participants in the untrained group were informed at the study kickoff meeting they would receive formal in-person instructor training on all interventions in weeks 19, 20, and 21 following the end of data collection.

Importance of Study

The present study provided quantitative information on the effects of ergonomic product intervention and training on productivity and comfort. In addition, the present study addressed ergonomic issues considered in the work place including: allocation of ergonomic resources (budget and staffing), and the benefits of ergonomic product intervention versus training. The present study also provided information applicable to the workplace regarding the benefits and challenges involved with training on new ergonomic products and the effects of learning curves on computer productivity.

Definition of Terms

For the purposes of the present study, the following terms were defined:

Asymptomatic. Asymptomatic means no background of discomfort lasting more than 8 consecutive hours, and no medical diagnosis of ergonomic injury reported over the last three years.

Comfort. Comfort is a feeling of relaxation and well-being (Zhang, Helander & Drury, 1996).

Discomfort. Discomfort is a feeling of pain, irritation, numbness, tiredness, soreness, and tenderness (Zhang, L., & Helander, M., 1992).

Ergonomics. The applied, multidisciplinary science (and art) of reducing both the risk of on-the-job injuries and errors, and the simultaneous enhancement of human and system performance through the use of better tools, better work methods, better operating procedures, better training, and enhanced supervision and management techniques (Oxford Research Institute [ORI], 2005).

Ergonomist. An ergonomist is a professional having peer recognized formal training and/or certification in the field of Human Factors and Ergonomics. Ergonomists typically examine and analyze work activities, tool design, man-machine interfaces, and injury data trends to determine how and where a particular injury or error rate can be either reduced, eliminated, or mitigated (ORI, 2005).

Ergonomic Training. Training, conducted by an Ergonomist, based on anthropometry, behavioral techniques, biomechanics, peer reviewed Human Factors and Ergonomics principles and guidelines, postures, and the use of ergonomic products that promote increased health and well being.

Hawthorne Effect. Hawthorne effects are described as an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important (Mayo, E., 1993). Hawthorne effects may help explain some of the findings in the present study.

Productivity. Productivity is the ratio formed by dividing the sum of all output measures by a denominator reflecting the sum of all input measures. A productivity measure or index is typically relative in nature and seldom used in the form of absolute values (ORI, 2005).

QWERTY Keyboard. A QWERTY keyboard is described as a standard or ergonomic keyboard that has the letters laid out in QWERTY form; that is, the top left hand row of letter keys begin with the letters Q, W, E, R, T, and Y.

CHAPTER 2

Review of Literature

The last several decades produced a number of important studies on the effects of ergonomic factors impacting healthy and productive computer work. Some studies included the examination of various wrist and forearm postures, wrist and forearm range of motion, and employee discomfort levels in relation to ergonomic keyboard design (Hallbeck, 1994; Hedge et al., 1999-1992; Marshall, 1999; Sauter, 1991; Serina, 1999; Simoneau, 1999). Other studies examined keyboard and/or keyboard tray design features in relationship to discomfort and performance (Hedge et al., 1995; Hedge, Goldstein, Hettinger, et al. 2002; Muss & Hedge, 1999; Oates et al., 1998; Silva, Malafronte, et al. 2002; Smith et al., 1998). The studies in the present review of literature were included because productivity, comfort, and ergonomic intervention variables were measured.

Various symptoms and ergonomic injuries have been identified in the literature. While one study specifically researched symptoms related to carpal tunnel syndrome (Stevens, Witt, Smith & Weaver, 2001), others researched symptoms related to all types of repetitive strain injuries (Simoneau, Marklin & Monroe, 1999; Tittiranonda, Rempel, Armstrong & Burastero, 1999). Few experiments, however, examined the impact of training or, specifically, training affects on the productivity curve related to the introduction of new ergonomic products in the workplace (Karlvist et al., 1994; Swanson et al., 1997; Zecevic et al., 2000). The present review of the literature is focused on pertinent keyboard studies performed over the last five years, and on several older, related studies. The research studies presented in the current review of literature were found in scholarly journals including: *American Industrial Hygiene Association, Applied Ergonomics, Ergonomics*, and *Human Factors*.

Supplemental information was found within general industry guidelines such as: American National Standards Institute (ANSI), Bureau of Labor Statistics (BLS), and the National Institute of Occupational Safety and Health (NIOSH). A review of the above referenced literature revealed trends that were indicative of ergonomic research paradigms from 1980 through the mid 1990s. Trends found in the literature included the use of small samples (less than 50), short experimental duration (less than 4 weeks), extensive weight placed on "perceived comfort" as a key experimental design criterion, and use of productivity and baseline questionnaires (Hedge et al., 1995; Radwin & Jeng, 1997; Sauter & Schleifer, 1991; Swanson et al., 1997).

Other general themes in the research included a focus on physiology and frequency of wrist injury; posture and musculoskeletal discomfort; wrist and forearm range of motion and flexion, extension, ulnar and radial deviation effects and limits. Those studies that investigated comfort in relation to ergonomics have sought to establish baseline musculoskeletal discomfort levels for the participants by providing a relatively standardized pre test comfort questionnaire (David, G., & Buckle, P.A., 1995; Hedge et al., 1999; Hedge et al., 2002; McAtamney & Corlett, 1993; Nelson & Silverstein, 1998). All researchers chose to establish an ergonomic baseline for the participants by performing pre test ergonomic workstation alterations. Possible reasons for similarity in experimental method and design over the last decade include: 1) use of tested and reliable methods to present evidence that ergonomic interventions are beneficial to user productivity and comfort; and 2) use of basic research guidelines and protocol promoting new experiments to build on (as opposed to displacing) past research.

Most ergonomic intervention studies performed over the last decade were similar to each other in design and focus, although, a few ventured into unique territories and were indicative of shifting paradigms for current ergonomic research. The shift emphasized a stronger focus on product design and training in relation to user productivity, comfort, and long term user health and wellness. The use of online experimental questionnaires and quantitative measures of productivity were additional innovations of the current research approach. Since the mid 1990's there have been some interesting non traditional findings from traditional ergonomic research methods. Interesting topics included: the physiology and frequency of ergonomic injuries, the effects of product design and training on productivity in the work place, and the effects of workplace interventions. Following is a discussion of some experimental trends indicative of shifting paradigms in ergonomic research over recent years.

Physiology and Frequency of Ergonomic Wrist Injury

The physiology and frequency studies included in the present review of literature focused on wrist injury neuronal activity and frequency of carpal tunnel syndrome in the workplace. Important findings on the effects of complex wrist and forearm posture and wrist range of motion showed that combinations of wrist/forearm postures negatively affected wrist range of motion, particularly wrist flexion/extension in relation to radial deviation range of motion. Marshall et al. (1999) noted a large variation in results when manual, as opposed to electronic, measurements of wrist deviations were employed.

The Marshall et al. findings implied a greater degree of precision was afforded by the use of electrogoniometers when performing risk assessments, as opposed to the use of more standard measuring devices such as rulers and measuring tapes.

In 1994, Caplan's physiological study showed that fine motor movements begin in the primary motor cortex portion of the brain, and non neutral wrist postures generate more neuronal activity than neutral wrist postures, therefore increasing risk of ergonomic injury (Caplan, Posner, & Cheney, 1994). Another physiological study researched aspects of movement represented in the primary motor cortex (M 1) by recording neuron activity of wrist movement, direction and muscle activity (Shinji, Hoffman, & Strick, 1999). Shinji et al. (1999) focused on relatively low level and abstract parameters like muscle force and hand path. Surprisingly, it was found that more neurons (44 out of 88) showed changes in activity than expected, and that the neuronal changes represented in M 1 are related to the direction of wrist movement in space independent of the pattern of muscle activity that generated the movement (Shinji et al., 1999).

In 2001, Stevens et al. studied the frequency of carpal tunnel syndrome in comparison with assessed estimated frequency of same. Of the 257 participants studied, there was no significant difference was found in the characteristics and symptoms of employees with and without carpal tunnel syndrome. The study revealed that keyboard trays may not be the causative factor in ergonomic injuries, as the hand symptoms found in users diagnosed with carpal tunnel syndrome were comparable to those symptomatic users who were diagnosed as not having carpal tunnel syndrome (Stevens et al., 2001).

The Stevens et al. findings indicated that keyboard design may not be as instrumental in reducing injury as previously thought and that employees may have similar symptoms whether or not they have been medically diagnosed with carpal tunnel syndrome. However, according to Hedge et al. (2002), adjustable ergonomic keyboards may help reduce upper extremity musculoskeletal disorders.

Workplace Studies: Product Design and Posture

Over the last few years, many keyboard design studies were performed by leveraging various combinations of the same group of basic researchers. Researchers streamlined their designs and procedures by taking each investigator's specializations into account and by using reliable experimental methods for various phases of data collection. Within the last decade, for instance, Hedge, McCrobie, and Morimoto have consistently collaborated with one another on valuable ergonomic intervention studies involving traditional laboratory based methods of ergonomic research. Some of their most recent research indicated that preset tilt down keyboard trays provided significant improvements to wrist postures and musculoskeletal discomfort, and encouraged good seated posture (Hedge et al., 1994).

The Hedge et al. studies (1995-1999) used video-motion analysis and electrogoniometers to research hand/wrist postures on QWERTY keyboards. Three conditions tested were: 1) typing without arm support; 2) typing with adjustable full motion forearm support; and 3) typing with an adjustable negative slope keyboard tray. Results indicated that most participants adjusted the keyboard tray slope around 12° below horizontal; ulnar deviation was comparable at all three conditions, and averaged

13° for the right hand and 15° for the left hand; and that arm supports did not significantly affect posture (Hedge et al., 1995). In a later study these researchers extended their own ideas by studying 38 office workers (Hedge et al., 1999). They studied the effects of negative keyboard platform slope and musculoskeletal discomfort, and found that negative keyboard platform slopes afforded neutral wrist postures, decreased musculoskeletal discomfort, and users had a positive reaction to the negative slope position. Experimental methods borrowed from past studies and used in the present study included: similar experimental design; customized version of the Hedge et al., comfort questionnaire; and establishment of baselines for participants by performing pre test ergonomic workstation consultations.

Other workplace studies indicated the best keyboard designs involved an ideal combination of force, posture, comfort, and productivity (Smutz, Serina, & Rempel, 1994); and keyboard designs had an impact on fatigue, comfort, and productivity over a two-day exposure (Swanson et al., 1997). Zecevic et al. (2000) found the introduction of an ergonomic keyboard accompanied by an initial 10% decrease in productivity and improvements in hand postures. The decrease in productivity may have been associated with the new product learning curve, and the improvements in hand postures were hypothesized to reduce potential wrist injury. One recent study showed users found split/angled keyboards to be more comfortable than standard ones, and angled keyboards (no split) significantly reduced mean wrist extension. The reduction in wrist extension using an angled keyboard (no split) was speculated to be due to the palmer support provided (Tittiranonda et al., 1999).

Zecevic et al. (2000) compared three keyboard designs (standard, fixed angle, and open adjustable angle) and found no significant differences in productivity between the standard and fixed angle keyboards, although both were user-preferred to the open adjustable angle keyboard design. The keyboard comparison illustrated, although there may be initial decreases in productivity (up to 10%), more neutral hand postures afforded from using an open adjustable angle ergonomic keyboard, may reduce potential wrist injury incurred when using the fixed keyboard design. The Zecevic et al. (2000) study found the fixed angle keyboard design preserved the most reasonable level of productivity, and was the most user friendly. Prior to the Zecevic et al. study, Karlzvist, Hagbert, and Selin (1994) suggested that the initial decrease in productivity seen when a new keyboard design was introduced may have been associated with the user acclimating to the change in keyboard style, particularly when the number pad was eliminated from the keyboard design. The experimental methods taken from these studies for the present study involved research on productivity trends in relation to new product introduction and the effects of training on productivity.

Hedge and Powers (1995) conducted a study focusing on ulnar deviation. Hedge and Powers found the use of angled keyboards decreased extensor muscular strain, workers usually tilted adjustable keyboard platforms to around 12° below horizontal, arm supports did not significantly affect wrist posture, typists generally work with wrists in non-neutral angles, approximately 73% of participants typed with one hand at greater than 15° extension, and 20% of participants typed with one hand at greater than 20° ulnar deviation. Hedge and Powers observed typists' body postures and joint motions, and focused on quantitative degree of freedom values using an electrogoniometer to record wrist and forearm angles for 25 participants typing for 10 to 15 minute periods at a standard workstation.

A couple of studies focused on wrist posture while inputting on the computer, and found differences between right and left hand strain while performing various tasks on manual and electronic keyboards (Simoneau et al., 1999; Serina et al. 1999). Serena et al. (1999) found no significant difference between alphanumeric and alphabetical tasks in relation to wrist posture, but the left wrist showed significantly greater mean ulnar deviation than the right wrist, and the right forearm had greater mean pronation than the left forearm. The data collected from the studies reviewed in this section were relevant to keyboard design and emphasized the importance of focusing on the left [non dominant] hand while performing ergonomic assessments and retraining (Simoneau et al., 1999).

Workplace Interventions

Fisher et al. (1993) found that job parameters can be set to achieve increased productivity and decreased repetitive motion disorders. Fisher et al. developed job parameters as an alternative to the traditional fixes such as job aids and engineering redesign. The job parameters included varied rate of work; and the number and duration of the rest breaks built into tasks. One point to note is that some ergonomic standards give specific guidelines as to appropriate hierarchy of controls as follows: 1) engineering; 2) administrative; and 3) personal protective equipment. Rest breaks, as they relate to the

Fisher et al. findings would be categorized under "administrative" control which is considered a secondary safety measure (CalOSHA, Section 5110).

Nelson and Silverstein (1998) developed a study to identify factors associated with reduced office ergonomic injuries and found that reduced musculoskeletal symptoms may be associated with the following: chair comfort, reduced housekeeping responsibilities, female gender, and lower pay rates. Their study involved 577 participants moving from nine original buildings into two ergonomically designed buildings. The original buildings had a variety of older non adjustable furniture. The newer buildings had modular furniture and ergonomic chairs. Nelson and Silverstein tested for hand/arm and neck/shoulder/back outcomes. Concerns regarding these findings are, the larger number of female participants may have reduced overall effect and that employees of lower pay rates may have been less likely to report discomfort.

Summary

The present review of literature focused on studies published between 1991 and 2002 related to the effects of product design on wrist injury physiology and frequency, productivity and comfort, and workstation intervention. Overall findings indicated that neuronal activity increases in the presence of ergonomic injury, product design, and training affected productivity, employees without diagnosed carpal tunnel syndrome can have equal levels of discomfort and number of symptoms to those diagnosed, and workstation interventions make a difference in the reduction of discomfort and injury in the workplace. Finally, there is a shifting paradigm in the field of Human Factors and Ergonomics pointing to further study of the benefits of workplace intervention, particularly, the effects of training on productivity in relation to new product implementation.

CHAPTER 3

Methods

This chapter includes a discussion of participant demographics, and an overview of instruments, procedures, training tools, tasks, design, and data analysis used in the present study. The present study provided quantitative information on the effects of training on productivity and comfort, and addressed ergonomic issues considered in the work place including: allocation of ergonomic resources (budget and staffing), the benefits of ergonomic training versus product intervention, the benefits and challenges involved with training on new ergonomic products, and the effects of learning curves on computer productivity.

The study was longitudinal over four months with multiple ergonomic interventions. Ergonomic interventions were implemented at the end of months 1, 2, and 3. The study included installation of a keyboard tray after the first month, an ergonomic keyboard after the second month, and a 45 minute web based ergonomic training after the third month. Individualized in-person instructor training was provided on each intervention for approximately half of the participants (n=14).

Participants

Participants were publicly recruited from a large university campus via common area news releases, emails, fliers, and word of mouth. Approximately 100 potential participants responded to the volunteer recruitment requests. Prior to the start of the study (at the kick off meeting) 55 volunteer participants were eliminated or dropped out of their own personal volition. In between the kickoff meeting and start date, 10 additional volunteer participants dropped out, and another five dropped out for various reasons during the study. Reasons the first 55 were eliminated included the use of a MAC platform that is not compatible with RSIGuard software; increased job responsibilities due to University of California, Santa Barbara (UCSB) budget cuts and layoffs; and unwillingness to participate in a 4 month long study. Of the five participants that dropped out during the study, two participants dropped out due to on campus transfers and one dropped out due to job change to another company. The remaining two participants dropped out due to extended vacation that would have biased the data.

The 30 participants were randomly assigned to trained (n=14) versus untrained (n=16) groups. Participant work tasks were homogeneous across groups and included general office work on similar style personal computers approximately 4 to 8 hours per day, 5 days a week. Within participant work tasks there was variation to the extent that some employees were consistently keying a maximum of 8 hours per day, whereas others were keying a variety of durations greater than four hours per day. Some participants were in work cycle driven environments with consistent monthly project due dates. Cycle driven work environments were specified in Table 2: Career Demographics as "Accounting/Finance." The data in Tables 1 through 3 detailed a variety of participant demographics broken down by trained versus untrained group including: body type, career, and computer use.

Detailed in Table 1 is the participant baseline data including: age, gender, height, body size, and dominant hand. Detailed in Table 2 is the participant baseline date including: typing experience, job type, average time at current job, average time in career field, whether participants have had a previous ergonomic evaluation, or wear glasses. Detailed in Table 3 is the participant baseline data including: work and home computer use, and average frequency and duration of breaks per day. The trained and untrained groups ages ranged from 18 to 64+ years. In the trained group, the 45-54 year range had the most participants. In the untrained group, the 55-64 year range had the most participants.

Both trained and untrained groups were composed of approximately 70% women, and 30% men. Average height of each group was approximately 65.5." Body types ranged from petite to large in both groups with the untrained group having slightly more medium sized participants than the untrained group. Both groups had approximately the same amounts of right versus left handed participants, with the untrained group having a slightly higher amount of left handed participants. The participant demographics provided in Tables 1 through 3 were collected via the online Pre Experiment Participant Demographic Questionnaire completed by each participant prior to starting the study (Appendix C).

Table 1

Pre Experiment Participant Demographics Survey Body Type Results by Group

Participant Criteria Category	Trained Group (14) Responses	Untrained Group (16) Responses
Age		
<24	2	0
25-34	3	4
35-44	3	4
45-54	4	1
55-64	2	6
>64	0	1
Gender		
Male	3	4
Female	11	12
Height (inches)	65.5	65.4
Body Size		
Petite	0	3
Small	2	0
Medium	5	9
Large	6	5
Extra Large	0	0
Dominant Hand		
Right	11	11
Left	3	5

Detailed in Table 1 are participant body type demographics including: age, gender, height, body size, and dominant hand.

Table 2

Pre Experiment Participant Demographics Survey Career Results by Group

Participant Criteria Category	Trained Group (14) Responses	Untrained Group (16) Responses
Typing Experience		
Beginner	0	2
Intermediate	7	11
Expert	7	3
Job Type		
General Office	10	13
Accounting/ Finance	3	4
Average Time: Current Job	6 years 6 months.	9 years 6 months
Average Time: Career Field	11 years 4 months	15 years 4 months
Previous Evaluation	4	6
Wears Glasses		
No	4	3
Reading	3	3
Regular	3	3
Bifocals	2	2
Trifocals	0	0
Contacts	0	3
Computer Glasses	0	1

Detailed in Table 2 are participant career demographics including: typing experience, job type, average time at current job, average time in career field, and whether participant has had a previous evaluation or not. Both groups had eye glass wearing participants, but the untrained group alone had one participant wearing computer glasses.

Table 3

Pre Experiment Participant Demographics Survey Computer Use Results by Group

Participant Criteria Category	Trained Group (14) Responses	Untrained Group (16) Responses
Work Computer Use (hours per day)	6.08	6.17
% Work Keyboard Use	58.08	60.00
% Work Mouse Use	38.08	35.87
Frequency of Work Breaks per day	2.25	2.60
Average Work Break Duration (minutes)	9.92	10.50
Home Computer Use (hours per day)	1.32	0.97
% Home Keyboard Use	43.81	26.50
% Home Mouse Use	59.75	60.83

Detailed in Table 3 are computer use demographics including: average work and home computer use, average percentage of work and home keyboard versus mouse use, and average work break frequency and duration.

Instruments

The Instruments used in the present study included the following: Study Overview Appendix A), Consent Form (Appendix B), Pre Experiment Participant Demographic Survey (Appendix C), Oral Directions to Participants presentation (Appendix D), Online Weekly Evaluation Survey (Appendix E), Ergonomic Product

Intervention Guides (Appendix F), RSIGuard 3.0 User's Guide & Summary of Data Logger Information (Appendix G), and a Detailed Training Procedure (Appendix H).

Following approval by the SJSU Human Subjects Institutional Review Board (HSIRB) (Appendix K), and prior to the start of the 30 day baseline, participant consent and demographic information were collected, and included information regarding: participants' rights and criteria, study parameters, medical history related to ergonomic injury and discomfort, and ergonomic equipment history (Appendices B, C, D). The Pre Experiment Participant Demographic Survey was modeled after Dr. Alan Hedge's typical design and consisted of questions related to individual medical history, personal discomfort symptoms, workstation and equipment training (Hedge et al., 2002). User discomfort data were collected prior to the experiment, and throughout the study, via an online subjective self assessment form (Appendices C, E). User discomfort data included: name and identification, reason for filing report, current pain level, normal/typical pain level, frequency of symptoms, current medical care, use of anti inflammatories, wrist braces, painkillers, location on body of symptoms (via checkboxes on a front/back image of body), and general comment information (Appendices B, D).

Remedy Interactive, Inc.'s RSIGuard 3.0 software program was used as a back up subjective comfort measure in the form of Health Status Reports, a feature which provided weekly reminders to fill out both the online comfort survey and the RSIGuard Health Status Report survey, weekly, throughout the length of the study. RSIGuard 3.0

was used to quantitatively measure productivity daily. Data were collected weekly. The type of productivity information collected is detailed in the Procedures section following.

The Weekly Evaluation Survey consisted of questions related to individual medical history, personal discomfort symptoms, workstation layout, and equipment training. The Weekly Evaluation Survey was based on Dr. Alan Hedge's typical model (Hedge et al., 2002), and incorporates American National Standards Institute, Occupational Safety and Health Association, and Rapid Upper Limb Assessment (McAtamney & Corlett, 1993) guidelines (Appendix E).

Ergonomic product intervention installation guides (Appendix F) were provided by Humanscale Corporation, Kensington, Inc., and Remedy Interactive, Inc. The keyboard tray and ergonomic keyboard user guides were standard instruction handouts provided by the manufacturers, and provided detailed information on the features and use of the products along with some general ergonomic principles (Appendix F).

Prior to the start of the study, participants used similar standardized workstations and equipment comprised of a chair, work surface, personal computer, and mouse (Appendix H, Figure H1). The typical campus keyboard and mouse were the Hewlett Packard standard issue keyboard (Appendix H, Figure H2) or one of comparable design. The mouse design and size varied slightly and may have affected mouse data collection with regard to Total Mouse Distance traveled, that is, slightly smaller mice (in relation to the work surface and mouse pad) might have greater travel distance than slightly larger mice.

The ergonomic keyboard trays were donated by Humanscale Corporation, and were configured with the 2G mechanism, keyboard platform, and dominant hand mouse platform (Appendix H, Figure H1). No agreement existed with Humanscale Corporation that the product would be found to be superior to the standard work surface. Features that distinguished the Humanscale ergonomic keyboard tray from a standard work surface were as follows: vertical, horizontal, and near/far keyboard platform adjustment; 180° radius dominant hand mouse platform swivel adjustment; platform tilt from neutral to 15° negative; and built-in palm support.

The ergonomic keyboards were donated by Kensington Ergonomic Products, Inc. and included the attached number pad (Appendix H, Figure H3). No agreement existed with Kensington Ergonomic Products, Inc. that the Comfort Type Keyboard product would be found to be superior in any way to the standard issue personal computer keyboard. Features that distinguished the Kensington ergonomic keyboard from a standard issue keyboard are as follows: ~15° fixed adjustment for wrist splay in the horizontal plane, editing key layout for left-right work distribution, large space bars, full size, tactile feedback keys with soft end stop, low noise key actuation, and standard alphabetical QWERTY key layout. In the present study, keyboard design included the number pad. Users had the option of using imbedded numbers along the top of the keyboard versus the standard attached number pad.

Remedy Interactive, Inc.'s Office Ergonomic Suite software programs were donated for the trained versus untrained group comparison. No agreement existed with Remedy Interactive, Inc. that the product would be found to be superior in any way to in-person instructor training by an ergonomist. Features that distinguished the ergonomic web based training from in-person instructor training were as follows: user ability to complete training at own pace, and reliable standardized interactive program.

Ergonomic training services were donated and provided by the Principal Investigator and Elysian Integrated Health Solutions (formerly known as Total Body Ergonomics). Further training details can be found in the Procedures section.

Procedures

Volunteers were recruited internally from University of California, Santa Barbara (UCSB) campus wide staffing pool (population ~6,000). Recruiting techniques included site-wide email and voicemail requests, and lobby and break room advertisement. Participants were selected based on availability, with Principle Investigator intent to have approximately 50% male and 50% female. Participants were randomly assigned to symptom free trained (n=14) and untrained (n=16) groups. Potential participants completed a pre-study online questionnaire designed to assess the presence or absence of ergonomic symptoms (Appendix C). All participants underwent an initial kickoff meeting discussing the detailed procedures of the experiment including purpose, method, instruments, discomfort questionnaires, weekly surveys, and study duration (Appendix C). All participants were required to complete a consent form (Appendix B).

One week prior to the study start date, respective departmental Internal Technology employees installed the RSIGuard 3.0 software program for each participant to measure a baseline for individual productivity in the workplace. Participants were not required to interact with RSIGuard, but were aware of its existence. In an effort to minimize confounders related to chair and monitor ergonomic risk factors, at the onset of the study all participants had a consultation regarding adjustment of their existing workstation, monitor, and chair height to coincide with anthropometric guidelines (Appendix H, Figure H5). Workstation adjustments and training were provided by professional ergonomists. The length of the initial 30 day baseline was specifically designed to offset any confounding effects on productivity and comfort due to the initial consultation. User comfort data was collected weekly throughout the study by means of an online Weekly Evaluation Survey (Appendix E) used in prior keyboard evaluation research (Hedge et al., 2002), which was maintained and administered by Dawn Armstrong, the Principal Investigator. Participants completed the online Weekly Evaluation Survey at approximately the same time each week for the duration of the study.

Productivity data were collected using the automated performance assessment capabilities of RSIGuard 3.0. Usual job related typing tasks allowed RSIGuard to gather statistical data measuring the effect of training on productivity over time. Productivity data were collected each work day by the RSIGuard 3.0 software program. Productivity data collected are detailed in Table 4. Of the 23 possible keyboard and mouse related quantitative variables (Appendix G), eight were chosen to be relevant to this particular study; four were keyboard related, three were mouse related, and one was jointly mouse and keyboard related. Although eight were chosen, only six had significant results as detailed in Chapter 4, Results.

Table 4

Present Study Productivity Variable Measures

Productivity Variable Name	Measure
Keyboard Work Seconds	Number of hours using keyboard.
Keyboard Clicks	Keystroke frequency by key. Use is expressed as a percentage of total key pressing.
Keyboard Word Count	Number of words typed.
Keyboard Errors	Number of typing corrections. Shows how many times you pressed sequences of Delete or Back-space keys.
Mouse Work Seconds	Number of hours using Mouse.
Mouse Clicks	Number of Mouse Clicks performed each day.
Total Mouse Distance	Estimate of how much mouse movement you performed each day.
Mouse/Keyboard Switches	Number of times switched from (i.e. moved your arm between) the mouse to the keyboard or vice-versa.

Ergonomic interventions (keyboard tray, ergonomic keyboard, web based training) were implemented at key points throughout the study as detailed in Table 5. During the week prior to the start of the study, ergonomists made minor chair and monitor adjustments, and overviewed ergonomic basics including neutral postures and keying principles for all participants. Following the 30 day baseline all participants were allocated keyboard trays and half were provided with explicit instruction on use, while the remaining half were provided with only the User Instruction Guide (Appendices F, H). Following the 60 day data collection, all participants had ergonomic keyboards installed and half were provided with explicit instruction on use, while the remaining half was only provided with the User Instruction Guide (Appendices F, H). Following the 90 day data collection, the trained group was provided with Remedy Interactive's Office Ergonomic Suite ergonomic web based training and was assisted and trained on download, customization, and use of the product. RSIGuard 3.0 and Office Ergonomic Suite were downloaded off of website and website directions rather than installed from a packaged box.

Table 5

Study Intervention and Data Collection by Week

Months	Chronological Study Weeks				
Month 1 Baseline Data	Week 1 3/29-4/2 2004	Week 2 4/5-4/9 2004	Week 3 4/12-4/16 2004	Week 4 4/19-4/23 2004	Week 5 4/26-4/30 2004 Keyboard Tray Installs
Month 2 Keyboard Tray Data	Week 6 5/3-5/7 2004	Week 7 5/10-5/14 2004	Week 8 5/17-5/21 2004	Week 9 5/24-5/28 2004 Ergonomic Keyboard Installs	
Month 3 Ergonomic Keyboard Data	Week 10 6/1-6/4 2004 Holiday	Week 11 6/7-6/11 2004	Week 12 6/14-6/18 2004	Week 13 6/21-6/25 2004	
Month 4 Training & Intervention Data	Week 14 6/26-7/2 2004 Web based Training Installs	Week 15 7/6-7/9 2004 Holiday	Week 16 7/12-7/16 2004	Week 17 7/19-7/23 2004	Week 18 7/26-7/30 2004
Month 5 Post Study Training	Week 19 Untrained Group Training	Week 20 Untrained Group Training	Week 21 Untrained Group Training	Week 22 Untrained Group Training	

Participant Training

Groups were subdivided into trained (n=14) and untrained (n=16) conditions and had no previous formal experience in the use of interventions provided: the keyboard tray, ergonomic keyboard, and ergonomic web based training. Participants in the trained condition received thorough training in the set up and use of each intervention. Participants in the untrained condition received no formal training beyond what was available to them on or inside the original packaging. The purpose of this manipulation was to examine the importance of formal training on the use of ergonomic tools and its impacts on improvements in productivity and comfort.

Pre baseline consultation was provided for all participants (separately from the productivity variable training) and lasted from 15 to 30 minutes per person. A pre baseline consultation comprised of the following types of training: 1) Online Weekly Evaluation Survey completion; 2) neutral wrist posture and whole arm movement keying principles; and 3) minor adjustments to wrist posture, chair and monitor. To ensure comprehension of, and familiarity with, the principles and tasks involved in the study participants were given mini field tests at the end of each pre baseline consultation (Appendix H).

Ergonomic intervention training was provided for participants in the trained group, lasting from 15 to 30 minutes per person and was comprised of the following: 1) Humanscale 2G Keyboard Tray adjustment (Appendix H), features and use; 2) Kensington Comfort Type Keyboard installation, features and use (Appendix H); and 3) Remedy Interactive Office Ergonomic Suite installation (Appendix H), features and use. To ensure comprehension of and familiarity with the principles and tasks involved, participants were given mini field tests at the end of each training section. Completion of the mini field tests required participant demonstration of equipment use as deemed acceptable by the attending ergonomist. If participants were not initially able to demonstrate acceptable use of the equipment, the ergonomist worked with them individually until the participant interacted with the equipment to standard requirements.

Tasks

Approximately 30 participants were studied as they performed daily work duties including heavy computer inputting (i.e., 20 or more hours of keyboarding activity per week). Throughout the duration of the experimental period, participants performed their usual work duties including keying tasks, telephone conferences, strategic planning meetings, and general office duties. Keying and telephone conferencing comprised a large part of each workday. Keying resulting in greater than 4 hours per day on average. All participants were asked to perform the computer inputting tasks normally associated with their work. No unusual or study specific keyboarding tasks were required.

Design

The present study was a multi factorial, mixed design. Independent variable training was measured as a between subjects variable with two levels (trained, untrained); and time was measured as a within subjects variable in four levels (30, 60, 90, and 120 days). There were eight dependent variable productivity measures as detailed in Table 4. The perceived discomfort level of participants was measured as: 1=slightly uncomfortable, 2=moderately uncomfortable, 3=very uncomfortable (Appendix E).

Participants were randomly assigned to two treatment groups, trained (n=14) and untrained (n=16). The discrepancy in equal n size was due to participant drop out, data holes, and scheduling challenges. Null hypotheses included: 1) ergonomic product intervention will not affect productivity and discomfort; 2) training will not affect productivity and discomfort; and 3) ergonomic intervention and training will not interact to affect productivity and discomfort.

Analysis of Data

The duration of the study was 120 days. Productivity and comfort results were sampled on a weekly basis throughout the study and were used to examine the effects of training on productivity and comfort over time. A data set comprised of dependent measures obtained during the first month of the study was analyzed to assess baseline data. Data sets comprised of dependent measures obtained 1 week after each intervention were analyzed to assess short term effects. The entire 120-day data set was analyzed to examine longer term effects. Data were also analyzed at weekly, bi weekly, monthly, and pre versus post study intervals. Significant interactions were found at all data sample intervals. For the purposes of the Methods chapter, bi weekly or 2-week period intervals were discussed, as the greatest frequency of significant results was found when analyzed across 2-week intervals. For additional information on analysis of other time intervals, see Appendix I and Appendix J.

CHAPTER 4

Results

Data Collection Intervals

The findings of the statistical analyses of independent variables on dependent variables are presented in this results chapter in order to answer the questions addressed in the present study. Productivity data were analyzed across four time intervals: weekly intervals (duration 18 weeks), bi weekly intervals (10 weeks), monthly intervals (4 months), and pre versus post study intervals (end Month 1 and end Month 4). In order to comprise unbiased bi weekly data, it was necessary to take an average of the 5 weeks in months 1 and 3 respectively and create a simulated 6^{th} week for each month. Taking the 6^{th} week out of Month 2 would have confounded the results as the first ergonomic intervention would have been in place. Taking the 6^{th} week out of Month 5 would have confounded the results as the study would have been finished.

While the significant test effects were initially hypothesized to exist in weekly intervals, it was interesting to find frequency of significant results was greatest over a 2-week period. Additional significant results occurred in the pre versus post, monthly and weekly analyses. Although significant results were found in all intervals analyzed (additional data tables in Appendix I), the most effective way to present significant data was on a 2-week interval schedule. The 2-week interval results suggest new product learning curve parameters and may have an interesting impact on day to day ergonomic workplace practices and future studies. Chapter 5 provides a more detailed discussion of workplace impacts and future study implications.

Analysis of Variance Data - Productivity

Some of the benefits of using RSIGuard 3.0 software as the productivity measure in the study were that it provided quantitative results, a multitude of variables to choose from for data analysis, and an ease of use for study participants. While the participants were not blind to the software, it was seamless in that it remained hidden (minimized) on the bottom toolbar until needed. Although the data provided for up to 23 possible keyboard and mouse related quantitative variables (Appendix G), eight were chosen to be the most relevant to this particular study; four were keyboard related, three were mouse related and one was jointly mouse and keyboard related. The eight productivity measures (Keyboard Work Seconds, Keyboard Word Count, Keyboard Clicks, Keyboard Errors, Mouse Work Seconds, Mouse Clicks, Total Mouse Distance, and Mouse/Keyboard Switches) detailed in Chapter 3, Table 4 were chosen because they coincide with standard typing productivity measures. Many of the remaining 15 measures related to special features of the RSIGuard 3.0 stretch break program and auto click features which were not included in the study design. Although eight productivity measures were chosen for the purposes of the present study, only six revealed significant results and were included in the Chapter 4, Results section. Productivity measures that did not reveal statistically significant results in the bi weekly statistics presented in the present study included: Keyboard Errors and Keyboard Clicks.

Presented in Tables 6 through 17 are the ANOVAs and means for the six variables showing discussion worthy or significant data (Keyboard Work Seconds, Keyboard Word Count, Mouse Work Seconds, Mouse Clicks, Total Mouse Distance, and Mouse/Keyboard Switches).

Table 6

Summary of ANOVA Productivity Data for Keyboard Work Seconds: Training x 2-week intervals

Group	SS	df	MS	F
Training	55296315888.67	1	5.52963E+11	1.96
Error	535682278595.71	19	28193804137	
Weeks	4860485042514.89	9	5.40054E+11	60.50*
Weeks*Training	188016723707.96	9	20890747079	2.34*
Error (weeks)	1526539436145.76	171	8927131206	

*p < 0.05

Table 7

Descriptive Mean Keyboard Work Seconds Productivity Statistics by Group (2-week intervals)

Keyboard Work Seconds			
Training	N	Mean	Std. Deviation
Trained	9	3208513.74	2132935.52
Untrained	10	2191750.49	905885.63
Total	19	2673375.19	1644484.95

The results in Table 6 were found to be statistically significant for the variables weeks and weeks*training. Weeks related to Keyboard Work Seconds productivity over time ($F(9,171) = 60.50$, $p < .05$) and indicated that measured keyboard productivity time increased significantly for all participants over 10 consecutive 2-week periods. While it is possible that (based on Keyboard Work Seconds alone) the employees may have worked longer days and have not been using the computer keyboard at all, but rather spent time in meetings, Keyboard Work Seconds measures support increased Keyboard Work Second measures and validate the bi weekly interval data. The effect of training on Keyboard Work Seconds over time or weeks*training revealed statistically significant results ($F(9,171) = 2.34$, $p < .05$) and indicated that the increase in trained group productivity increased over all keyboard productivity significantly over 10 consecutive bi weekly periods. In Table 7, the mean Keyboard Work Seconds productivity was higher for the trained group (M=3208513.74) than for the untrained group (M=2191750.49) as indicated by the significant interaction in Table 6.

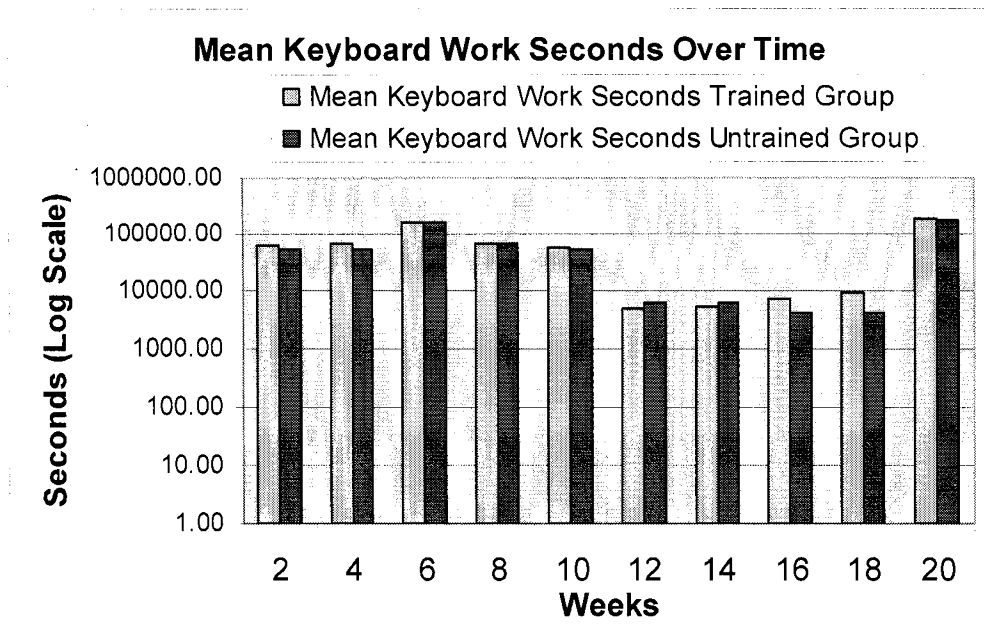

Figure 1. Graph of Mean Keyboard Work Seconds results over time by trained and untrained groups showing trained productivity consistently higher than untrained group. Logarithmic scale used as results range from 4191 to 181730 seconds.

Table 8

Summary of ANOVA Productivity Data for Keyboard Word Count:

Training x 2-week intervals

Group	SS	df	MS	F
Training	511944723.13	1	511944723.1	1.8
Error	5417597542.39	19	285136712.8	
Weeks	5149271350.88	9	572141261.2	12.58*
Weeks*training	626451207.64	9	69605689.74	1.53
Error (Weeks)	7778999071.89	171	45491222.64	

* $p < 0.05$

Table 9

Descriptive Mean Keyboard Word Count Productivity Statistics by Group

(2-week intervals)

Keyboard Word Count			
Training	N	M	Std. Deviation
Trained	9	110634.52	42633.59
Untrained	12	86549.78	43632.25
Total	21	96871.81	43855.29

The results in Table 8 were found to be statistically significant in the categories of weeks. Weeks related to Keyboard Word Count productivity over time

(F(9, 171) = 12.58, p < .05) and indicated an over all increase in Keyboard Word Count by all participants over 10 consecutive 2-week periods. In Table 9, the mean Keyboard Work Count productivity was higher for the trained group (M=110634.52) than for the untrained group (M=86549.78) as indicated by the significant interaction in Table 8.

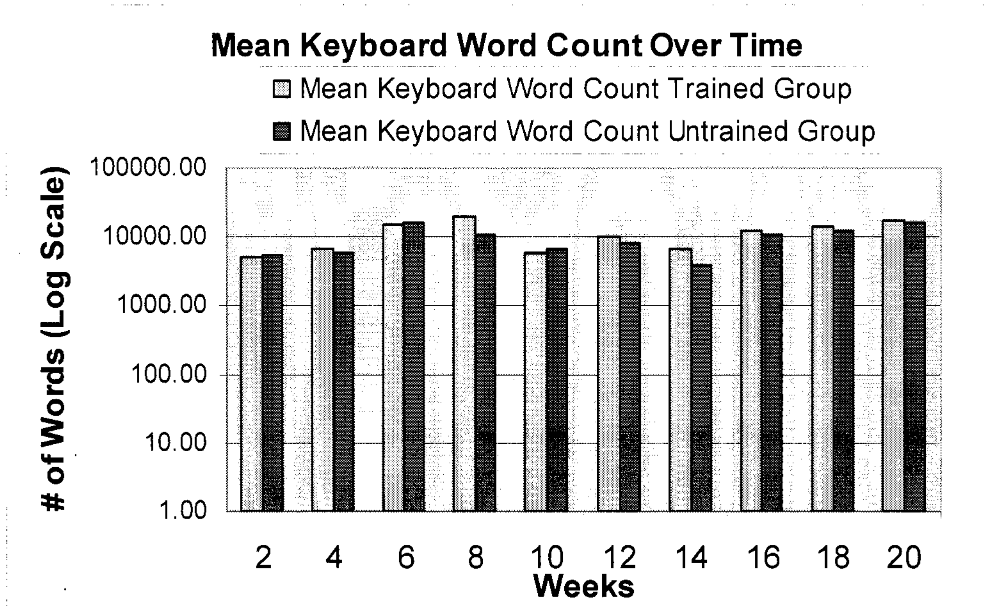

Figure 2. Graph of Mean Keyboard Word Count results over time by trained and untrained groups showing trained productivity consistently higher than untrained group. Logarithmic scale used as results range from 4044 to 19928 seconds.

Table 10

Summary of ANOVA Productivity Data for Mouse Work Seconds:

Training x 2-week intervals

Group	SS	df	MS	F
Training	1126793129788.14	1	1.12679E+12	3.50**
Error	5483991438789.49	17	3.22588E+11	
Weeks	51325790555329.80	9	5.70287E+12	59.43*
Weeks*training	3919602609407.71	9	4.35511E+11	4.54*
Error (Weeks)	14681982839892.33	153	95960672156	

*p < 0.05, ** p < 0.1

Table 11

Descriptive Mean Mouse Work Seconds Productivity Statistics by Group

(2-week intervals)

	Mouse Work Seconds		
Training	Mean	Mean	Std. Deviation
Trained	9	4417629.29	2242639.64
Untrained	10	2875731.09	1273897.18
Total	19	3606103.92	1916338.99

The results in Table 10 were found to be discussion worthy in the category of training and statistically significant in the categories of weeks, and weeks*training. In the trained group in-person instructor and web based ergonomic training made a positive influence on Mouse Work Seconds productivity as shown through 2-week intervals throughout the course of the study. Weeks related to Mouse Work Seconds productivity over time ($F(9, 153) = 59.43$, $p < .05$) and indicated that measured Mouse Work Seconds increased significantly over 10 consecutive 2-week periods for all participants. The effect of training on Mouse Work Seconds over time or weeks*training revealed statistically significant results ($F(9,153) = 4.54$, $p < .05$) and indicated that the increase in trained group productivity increased over all mouse productivity significantly over 10 consecutive bi weekly periods. In Table 11, the mean Mouse Work Seconds productivity was higher for the trained group (M=4417629.29) than for the untrained group (M=2875731.09) as indicated by the significant interaction in Table 10.

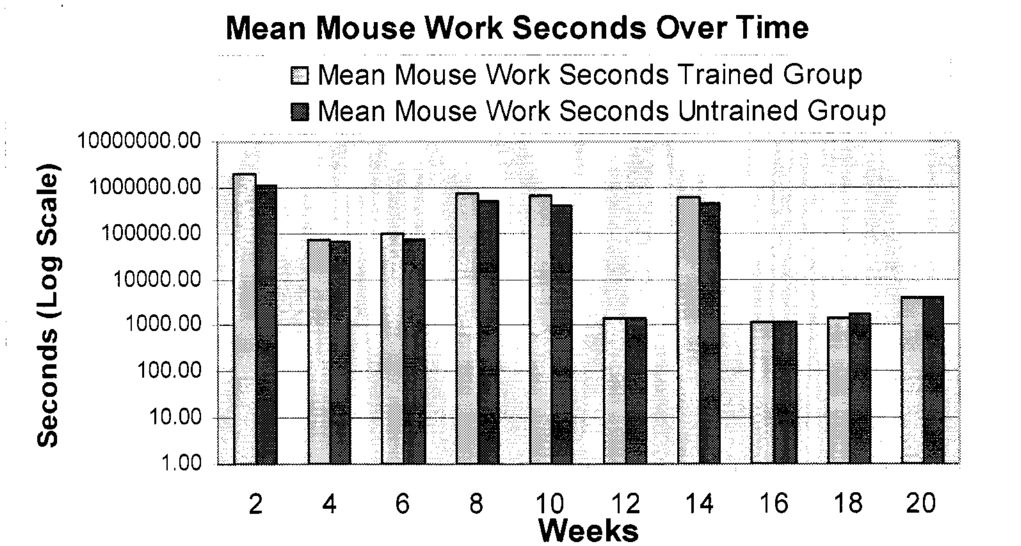

Figure 3. Graph of Mean Mouse Work Seconds results over time by trained and untrained groups showing trained productivity consistently higher than untrained group. Logarithmic scale used as results range from 1150 to 1902213 seconds.

Table 12

Summary of ANOVA Productivity Data for Mouse Clicks: Training x 2-week intervals

Group	SS	df	MS	F
Training	1664419496956.65	1	1.66442E+12	2.35
Error	12038824972832.36	17	7.08166E+11	
Weeks	53471384809905.90	9	5.94126E+12	36.26*
Weeks*training	3890823985655.57	9	4.32314E+11	2.64*
Error (Weeks)	25066714416791.10	153	16383473750	

*p < 0.05

Table 13

Descriptive Mean Mouse Clicks Productivity Statistics by Group (2-week intervals)

Mouse Clicks			
Training	N	Mean	Std. Deviation
Trained	9	3208513.74	2132935.52
Untrained	10	2191750.49	905885.63
Total	19	2673375.19	1644484.95

The results in Table 12 were found to be statistically significant in the categories of weeks and weeks*training. Weeks related to Mouse Clicks productivity over time ($F(9,153) = 36.26$, $p < .05$) and indicated an over all increase in Mouse Clicks by all participants over 10 consecutive 2-week periods. Weeks*training impacted the trained group mouse click productivity on the over all increase in Mouse Clicks by all participants ($F(9, 153) = 2.64$, $p < .05$). In Table 13, the mean Mouse Clicks productivity was higher for the trained group (M=3208513.74) than for the untrained group (M=2191750.49) as indicated by the significant interaction in Table 12.

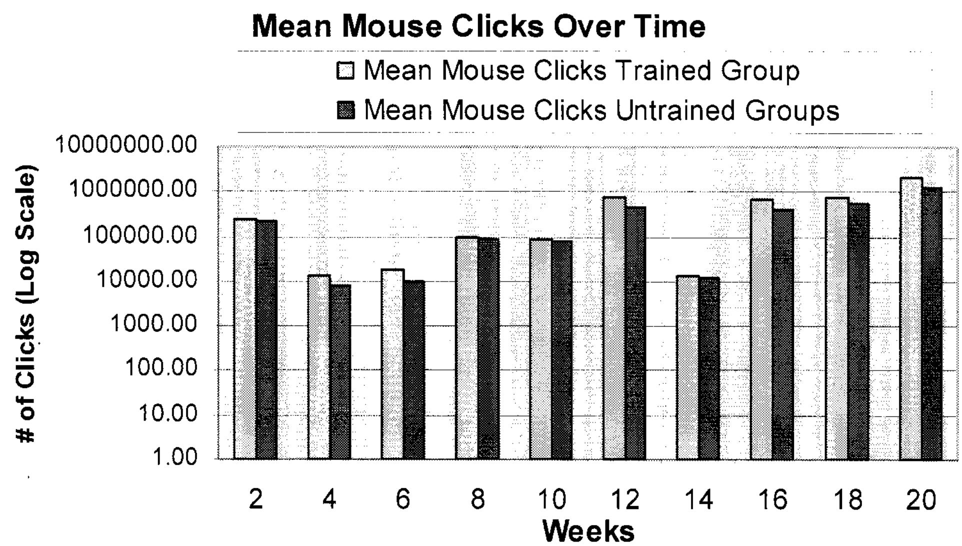

Figure 4. Graph of Mean Mouse Clicks results over time by trained and untrained groups showing trained productivity consistently higher than untrained group. Logarithmic scale used as results range from 8120 to 2111943 seconds.

Table 14

Summary of ANOVA Productivity Data for Total Mouse Distance:

Training x 2-week intervals

Group	SS	df	MS	F
Training	166174590699.57	1	1.66175E+11	4.83*
Error	584389882579.73	17	34375875446	
Weeks	8107203589466.82	9	9.008E+11	56.41*
Weeks*training	616970801539.04	9	68552311282	4.29*
Error (Weeks)	2443420768874.72	153	15970070385	

*$p < 0.05$

Table 15

Descriptive Mean Total Mouse Distance Productivity Statistics by Group

(2-week intervals)

Total Mouse Distance			
Training	N	Mean	Std. Deviation
Trained	9	1631336.81	664646.10
Untrained	10	1069998.90	466384.86
Total	19	1335895.81	622907.57

The results in Table 14 were found to be statistically significant for the variables training, weeks, and weeks*training. Training significantly impacted Total Mouse Distance and indicated that, within the trained group, there was a significant increase in productivity ($F(1,17) = 4.83$, $p < .05$). In the trained group in-person and web based ergonomic training made a positive influence on Total Mouse Distance productivity as shown through two week intervals throughout the course of the study. Weeks related to Total Mouse Distance productivity over time ($F(9,153) = 56.41$, $p < .05$) and indicated that measured Total Mouse Distance increased significantly over 10 consecutive 2-week periods for all participants. Weeks*training measured the effect of Total Mouse Distance increased in the trained group by Total Mouse Distance increased by all participants over 10 consecutive 2-week periods ($F(9, 153) = 4.29$, $p < .05$) and indicated that Total Mouse Distance significantly increased over ten consecutive 2-week periods. In Table 15, the mean Total Mouse Distance productivity was higher for the trained group (M=1631336.81) than for the untrained group (M=1069998.90) as indicated by the significant interaction in Table 14.

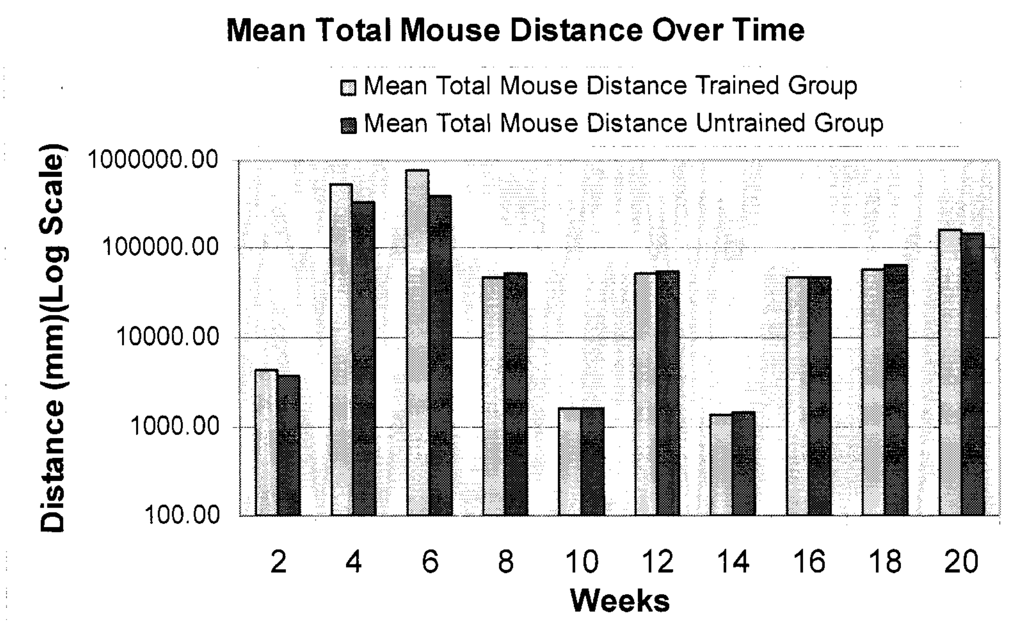

Figure 5. Graph of Mean Total Mouse Distance results over time by trained and untrained groups showing trained productivity consistently higher than untrained group. Logarithmic scale used as results range from 1336 to 775659 seconds.

Table 16

Summary of ANOVA Productivity Data for Mouse/Keyboard Switches:

Training x 2-week intervals

Group	SS	df	MS	F
Training	1449813755.73	1	1449813756	0.182
Error	135257251991.38	17	7956308941	
Weeks	1104676287154.84	9	1.22742E+11	90.33*
Weeks*training	5130655999.35	9	570072888.8	0.42
Error (Weeks)	207907046790.06	153	1358869587	

$*p < 0.05$

Table 17

Descriptive Mean Mouse/Keyboard Switches Productivity Statistics by Group (2-week intervals)

Mouse/Keyboard Switches			
Training	N	Mean	Std. Deviation
Trained	9	489422.06	142770.98
Untrained	10	458089.71	210119.22
Total	19	472931.35	177179.98

The results in Table 16 were found to be statistically significant for the variable weeks. Weeks related to Mouse/Keyboard Switches productivity over time ($F(9,153) = 90.33$, $p < .05$) and indicated an over all increase in Mouse/Keyboard Switches by all participants over 10 consecutive 2-week periods. In Table 17, the mean Mouse/Keyboard Switches productivity was higher for the trained group (M=489422.06) than for the untrained group (M=458089.71) as indicated by the significant interaction in Table 16.

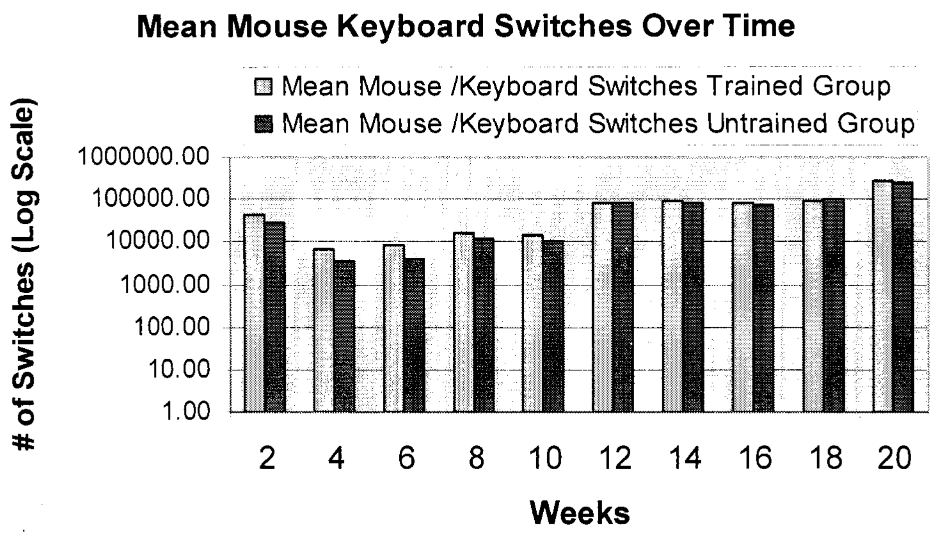

Figure 6. Graph of Mean Mouse Keyboard Switches results over time by trained and untrained groups showing trained productivity consistently higher than untrained group. Logarithmic scale used as results range from 3326 to 263977 seconds.

The results in Figures 1 through 6 indicate the mean productivity for the trained group was higher than the untrained group in the six statistically significant independent variables: Keyboard Work Seconds, Keyboard Word Count, Mouse Work Seconds, Mouse Clicks, Total Mouse Distance, Mouse/Keyboard Switches as shown over 10 consecutive 2-week intervals throughout the length of the study.

Analysis of Descriptive Data - Comfort

The tables and figures in this section detailed subjective comfort survey findings by body part from the pre study questionnaire and key weeks throughout the study. The pre study questionnaire provided a baseline to compare against weeks 7, 11, 14, and 18 which reflect installation of the keyboard tray, ergonomic keyboard, ergonomic web based training, and complete workstation redesign, respectively.

Discomfort responses were broken down into slightly uncomfortable, moderately uncomfortable, and very uncomfortable. Discomfort tables are an amalgam of only those participants that indicated discomfort in the online pre experiment and weekly evaluation surveys. Zero data from participants that were not experiencing discomfort was not included.

Table 18

Frequency of Discomfort Responses by Body Part Over Time Collapsed Across Trained and Untrained Groups

Body Part	Frequency of Pre Study Discomfort Responses	Frequency of Wk 7 Discomfort Responses	Frequency of Wk 11 Discomfort Responses	Frequency of Wk 14 Discomfort Responses	Frequency of Post Study Discomfort Responses	Total Discomfort Responses by Body Part
Neck	15	9	6	7	4	41
Right Shoulder	13	5	7	5	5	35
Left Shoulder	8	3	3	2	1	17
Upper Back	13	6	3	6	5	33
Right Upper Arm	5	2	2	4	1	14
Left Upper Arm	3	2	1	2	1	9
Lower Back	15	6	6	4	5	36
Right Forearm	4	2	3	3	1	13
Left Forearm	4	1	1	2	1	9
Right Wrist	11	3	7	6	3	30
Left Wrist	7	2	3	4	3	19
Total Responses by Week	98	41	42	45	30	256

A review of perceived discomfort data in Tables 18, 19, and 20 summarized frequency of discomfort responses, severity of discomfort responses, and percent reduction in frequency of discomfort responses. Detailed in Table 18 is a reduction in frequency of total discomfort responses over time from 98 to 30. Detailed in Table 19 are Pre versus post study frequency of severity responses including: slightly uncomfortable, moderately uncomfortable, and very uncomfortable. Detailed in Table 20 are percent reduction of response frequencies by body part collapsed across trained and untrained groups.

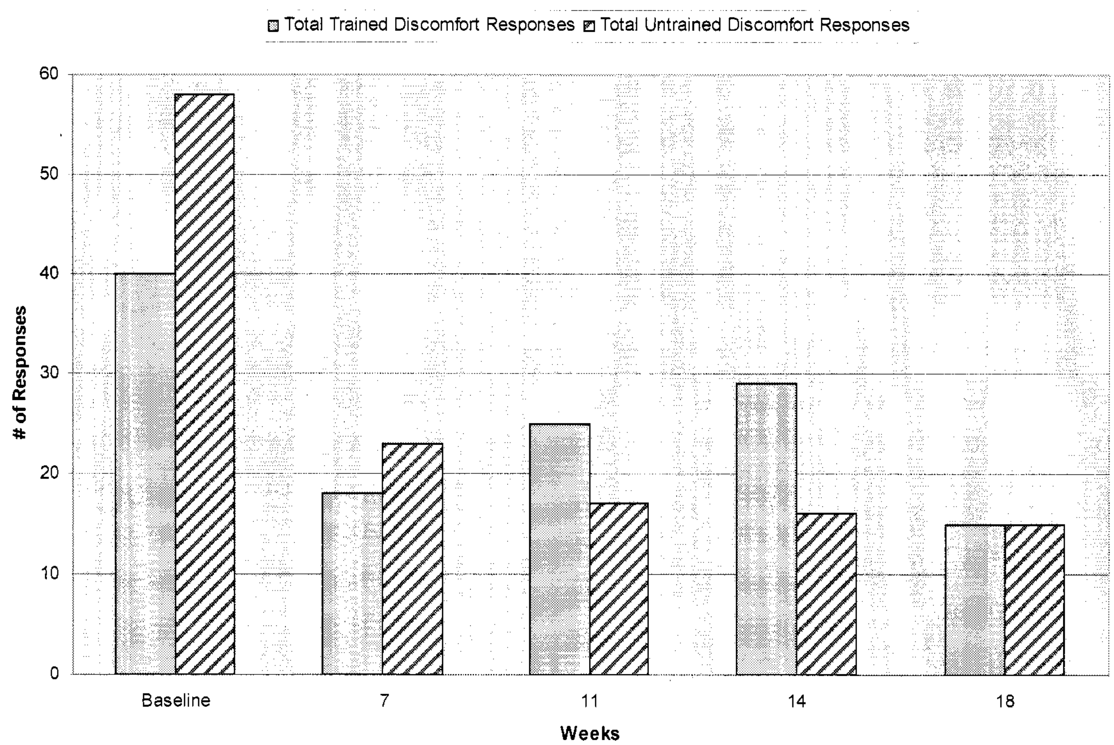

Figure 7. Graph of Total Trained and Untrained Frequency of Discomfort Responses Over Time indicating a decrease in total frequency of all three types of discomfort responses, slightly, moderately and very uncomfortable over time.

Figure 7 comfort results are higher for the untrained group at the start of the study, but drop by the end of the study. This may imply that the ergonomic product interventions (keyboard tray and keyboard) had a positive association with reduced musculoskeletal discomfort.

Detailed in Table 19 are findings that trained and untrained groups had similar response frequency through out the study for the slightly uncomfortable responses, but varied response frequency throughout the study for moderately uncomfortable and very uncomfortable severity levels. Detailed in Table 20 is an average reduction in frequency of discomfort responses of 70% by the end of the study, with an range of 57-87% reduction by individual body part.

Table 19

Frequency of Discomfort Responses by Body Part and Severity Level Over Time Collapsed Across Trained and Untrained Groups

Study Week	Slightly Uncomf. Responses Trained	Slightly Uncomf. Responses Untrained	Moderately Uncomf. Responses Trained	Moderately Uncomf. Responses Untrained	Very Uncomf. Responses Trained	Very Uncomf. Responses Untrained
Baseline	27	28	11	24	2	6
7	9	10	6	13	0	0
11	8	6	13	2	4	9
14	14	10	14	3	1	3
18	4	8	11	7	0	0

Table 20

Percent Reduced Frequency of Discomfort Responses Over Time Collapsed Across Trained and Untrained Groups

Body Part	Pre vs. Wk 7 % Reduced Frequency of Discomfort Responses	Wk 7 vs. Wk 11 % Reduced Frequency of Discomfort Responses	Wk 11 vs. Wk 14 % Reduced Frequency of Discomfort Responses	Wk 14 vs. Post % Reduced Frequency of Discomfort Responses	Pre vs. Post % Reduced Frequency of Discomfort Responses
Neck	40.00	33.33	-16.67	43.00	73.33
Rt Shoulder	61.54	-40.00	28.57	0.00	61.54
Lt Shoulder	62.50	0.00	33.33	50.00	87.50
Upper Back	53.85	50.00	-100.00	17.00	61.54
Rt Upper Arm	60.00	0.00	-100.00	75.00	80.00
Lt Upper Arm	33.33	50.00	-100.00	50.00	66.67
Lower Back	60.00	0.00	33.33	-25.00	66.67
Rt Forearm	50.00	-50.00	0.00	67.00	75.00
Lt Forearm	75.00	0.00	-100.00	50.00	75.00
Rt Wrist	72.73	-33.33	14.29	50.00	72.73
Lt Wrist	71.43	-50.00	-33.33	25.00	57.14
Total % Response	58.16% Reduction	-2.44% Increase	-7.14% Increase	33.00% Reduction	70.65% Reduction

The frequency of discomfort response severity levels by trained and untrained groups are found in Figures 8 through 10. Figure 8 shows frequency of slightly uncomfortable responses. Figure 9 shows frequency of moderately uncomfortable responses. Figure 10 shows frequency of very uncomfortable responses.

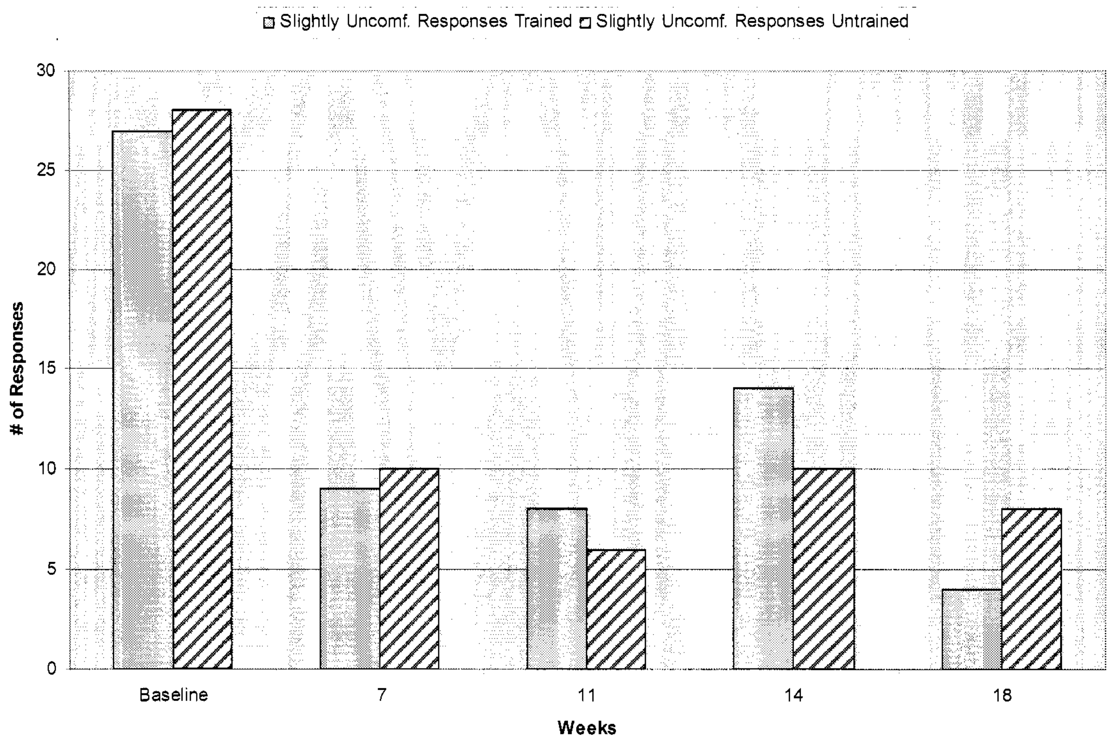

Figure 8. Graph of Frequency of Slightly Uncomfortable Discomfort Responses indicating a reduction in responses over time by Trained and Untrained Group

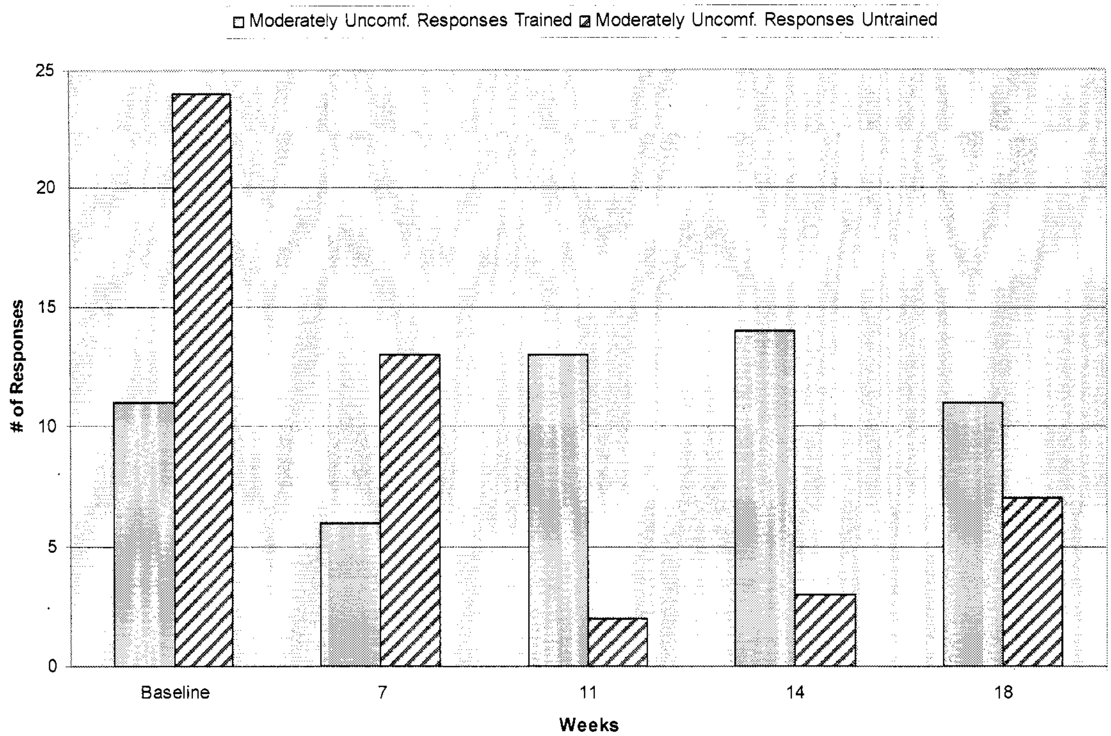

Figure 9. Graph of Frequency of Moderately Uncomfortable Discomfort Responses indicating a reduction in responses over time by Trained and Untrained Group

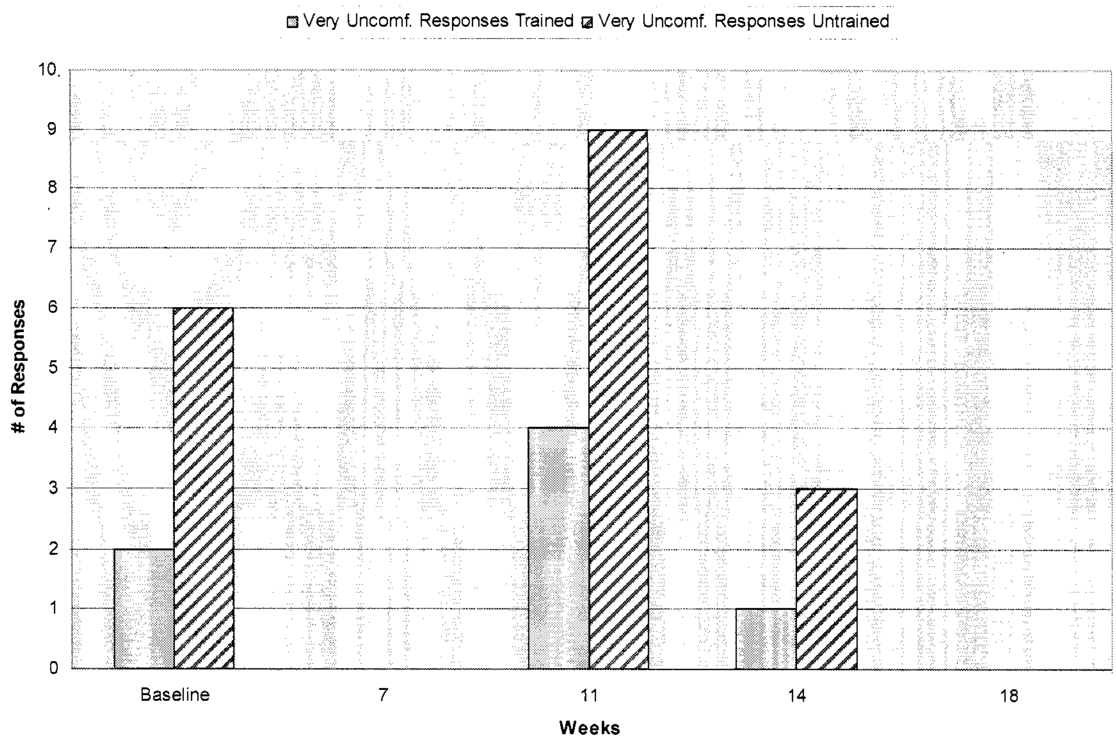

Figure 10. Graph of Frequency of Very Uncomfortable Discomfort Responses indicating a reduction over time by Trained and Untrained Group

Supplementary Findings: Design Changes

Some interesting twists occurred from the time the study design was originally approved in 2002 to the time it was implemented in 2004. Design changes included: adding a Humanscale 2G keyboard tray and Remedy Interactive's Office Ergonomic Suite as additional product interventions to the study design, and switching ergonomic keyboard design from Goldtouch, Inc. to Kensington Ergonomic Products, Inc. With the addition of the keyboard tray as a new product variable in the study design (reviewed and suggested by Dr. Alan Hedge of Cornell University), it was possible to examine more than one product intervention in relation to training, productivity, and comfort. With the addition of Office Ergonomic Suite, it was possible examine the differences between in-person instructor and web based training, and their potential effects on productivity and comfort. Lastly, adding additional products provided additional cost savings to the participating university (UCSB).

Supplementary Findings: Data Collection

In addition to product and study design changes, unexpected issues came up with regards to participation and data collection. Unexpected participation issues included vacation, sick, and weekend data holes, as well as a reduction in the number of projected participants. When reviewing and analyzing individual productivity data, zero days (0 productivity recorded) were removed to allow the SPSS statistical software program to perceive vacation, sick, and weekend days as missing data, as opposed to confounding effects reducing productivity.

Another data collection challenge was choosing appropriate intervention sample dates. During the 4 month long study, some months were 4 weeks long and some months were 5 weeks long. In addition, two months each had a holiday involved which created a 4-day work week. Detailed in Chapter 3, Table 5 is the ergonomic intervention timeline chosen in an effort to reduce the confounding effects of extra weeks and short weeks on data collection. Month 1 had 5 weeks which established baseline data. Months 2, 3, and 4 had interventions scheduled prior to a holiday week in an effort to better manage participant schedules with product installations.

Supplementary Findings: Additional Data

As originally expected, the RSIGuard 3.0 software data collection tool gathered an additional amount of quantitative productivity and subjective comfort data. Refining the gathered data to pertinent topics specifically related to the present study goals was a challenge. Significant interactive effects were found in the productivity data within all time intervals analyzed, but only 2-week interval data were presented as the findings for the present study. For additional information on pre, post, weekly and monthly productivity data please see Appendix I. Comfort data were collected for the upper and lower anatomy, but only upper body parts were presented as findings for the present study. For additional information on frequency of discomfort responses by body part and by trained vs. untrained group (Appendix J).

Summary of Results

In summary, the present study indicated the following: 1) ergonomic product interventions (keyboard tray and keyboard) significantly increase productivity and appear to have a positive association with reduced discomfort; 2) ergonomic interventions (keyboard tray, keyboard and a combination of in-person instructor and web based training) reduce musculoskeletal comfort; and 3) a combination of in-person instructor and web based training affect mean productivity positively (i.e., while both trained and untrained groups significantly increased productivity, the trained group consistently had a higher mean productivity over time).

CHAPTER 5

Discussion

Although many studies in the past have focused on the effects of ergonomic intervention on postural discomfort, the present study focused on the effects of ergonomic products (keyboard tray, ergonomic keyboard, and web based training) and training on productivity and comfort in the work place. With productivity as an important measure in the business world, a primary goal of the present study was to provide information applicable to the workplace with regards to the benefits or challenges involved with introducing new ergonomic products. The present study researched issues surrounding the introduction of new products, including: learning curve durations and their effects on computer productivity and perceived discomfort, and the benefits of training on new products.

The present study used best methods from, and supported many studies in, the present review of literature. Best methods included the use of a software program to collect data similar to Simoneau et al. (1999), and the use of a participant demographic and a weekly comfort evaluation similar to Hedge and Martin (1992).

Ergonomic Intervention Results

The ergonomic intervention results in the present study supported Hedge and Stack (1987, 88ab, p. 514-515) findings that "...keyboard tray did not impair typing performance" and "[keyboard tray] postural benefits should be similar for untrained [versus trained groups]." The present study also supported Nelson and Silverstein (1998) findings that ergonomic interventions helped reduce musculoskeletal symptoms. In the present study, both trained and untrained groups increased productivity throughout the duration of the study as each intervention was introduced, at the same time, musculoskeletal discomfort decreased by 57-87% for all body parts collapsed across both groups.

The present study findings support and extend Nelson and Silverstein (1998) findings that keyboards may help to alleviate symptoms. In the present study the interventions of the ergonomic keyboard and web based training affected frequency and severity of discomfort responses favorably.

The present study supported Tittironda et al. (1999) and Sauter et al. findings. Tittironda et al. results showed subjects found the adjustable keyboard to be more comfortable than the standard keyboard. Sauter, et al. results indicated that participants had more arm discomfort when the keyboard was above elbow height, ergonomic risk factors influenced musculoskeletal problems, and keyboards at low heights improved comfort. In the present study, "above elbow height" would relate to standard work surface heights of 28-30" from the floor.

Summary of Productivity Results

Significant results were found across bi weekly (2-week), pre versus post, monthly, and weekly time intervals. Bi weekly results were focused on throughout the present study as they had the greatest frequency of significant results. Additional productivity and comfort data are provided in Appendices I and J. Of the eight productivity variables measured (four keyboard, three mouse, one combination keyboard/mouse) significant results were found, primarily, in mouse related productivity measures. The three mouse variables: Mouse Clicks, Mouse Work Seconds, and Total Mouse Distance, and the combination variable Mouse/Keyboard Switches comprised the majority of the significant data at all time intervals. Keyboard Clicks, Keyboard Error, Keyboard Word Count, and Keyboard Work Seconds also contributed significantly, but were not found in all time intervals analyzed.

Learning Curve Results

The learning curve associated with using an unfamiliar product initially decreases productivity (Karlzvist et al., 1994). The present study specifically investigated the question, Are the effects (initial financial and productivity costs) associated with a learning curve worth the reduction in discomfort and eventual increase in productivity involved in the process; and if so, how long is the learning curve? In the present study the effects of ergonomic intervention (keyboard tray, ergonomic keyboard, and minor chair and monitor adjustments) on upper extremity postural discomfort were investigated.

Discussion worthy and significant results were found in the four time intervals analyzed (bi weekly, pre versus post, monthly, weekly), but most strongly represented in the bi weekly interval period suggesting that for the ergonomic keyboard tray and ergonomic keyboard used in the present study, the initial learning curve was not longer than 2 weeks.

The pre and post study analyses provided the second highest frequency of discussion worthy and significant results, suggesting the positive effects of ergonomic intervention and training increased as the study progressed. The monthly analyses provided the third highest frequency of discussion worthy and significant results, supporting the theory that the positive effects of new ergonomic products and training increase over time. The fact that the weekly analyses provided significant results in only one category (Total Mouse Distance) suggests that the full effects of training and new ergonomic products cannot be expected to show within the first week of use.

Keyboard Related Productivity Results

Keyboard Work Seconds and Keyboard Word Count were only significant for the bi weekly interval data. In both trained and untrained groups, Keyboard Work Seconds and Keyboard Word Count productivity improved throughout the course of the study as shown in the bi weekly data results. Because both trained and untrained groups improved Keyboard Work Seconds and Keyboard Word Count over time, the increased productivity may not be attributed to training. These results may indicate that the new products (keyboard tray and ergonomic keyboard) were responsible for the improvement in productivity.

Mouse Related Productivity Results

Since the study was originally designed to measure the effect of training on productivity and comfort using an ergonomic keyboard, the mouse related data was a welcome effect and suggests the one experimental design change (addition of keyboard tray) had an effect on mouse usage. In both trained and untrained groups individually, Mouse Work Seconds, Mouse Clicks, Total Mouse Distance and Mouse/Keyboard Switches productivity improved as shown through bi weekly intervals throughout the course of the study. These results may indicate that the new products (keyboard tray and ergonomic keyboard) were responsible for the improvement in productivity. In the trained group a combination of in-person instructor and web based ergonomic training had a positive influence on productivity.

Although, the increase in mouse productivity may be a welcome result, and supports the importance of further mouse research, the harmful effects of increased productivity require surveillance. Potentially harmful effects of increased mouse productivity include an increase in ergonomic risk factors such as repetition, duration, and awkward postures. Burgess-Limerick et al. (1999) found user's may have an increased risk of injury associated with prolonged exposure to input devices. The present study's increase in Mouse/Keyboard Switches productivity can be seen as improving ergonomic conditions. For example, increased Mouse/Keyboard Switches may spread the harmful effects of repetition more evenly between the mouse and keyboard tasks while also potentially reducing the static load, produced by excessive keyboard or mouse inputting, on upper extremities.

Summary of Comfort Results

In the present study participants completed an online weekly evaluation survey to measure variations in comfort over time for 11 body parts including: neck, upper back, lower back, right shoulder, left shoulder, right upper arm, left upper arm, right forearm, left forearm, right wrist and left wrist. Comfort data were only reviewed for those participants indicating discomfort. An overall decrease in frequency of discomfort responses was found throughout the study for all body parts. The pre study discomfort responses by body part totaled 98 and the post study discomfort responses by body part totaled 30 as detailed in Chapter 4, Table 18.

Detailed in Chapter 4, Table 19, are severity of discomfort responses which decreased for slightly uncomfortable, moderately uncomfortable, and very uncomfortable severities for trained and untrained groups over time. One exception was the trained group's moderately uncomfortable responses in which response severity level dropped by approximately 55% after the installation of the keyboard tray, but increased by approximately 70% after the introduction of the ergonomic keyboard and web based training, and finally stabilized by the end of the study as follows: Baseline = 11, Week 7 = 6, Week 11 = 13, Week 14= 14, Week 18 = 11. Reasons the trained group's moderately uncomfortable responses did not decrease as dramatically as the other two severities may include: 1) increased focus on discomfort and ergonomic awareness after the installation of the ergonomic keyboard and web based training interventions, and/or; 2) dissatisfaction in the work place due to imminent budget cuts and potential layoffs. Because the trained group's moderately uncomfortable responses did not show much change, the present study supported Hedge and Powers (1995, p. 509), "Computer users may be particularly at risk of CTS [carpal tunnel syndrome] because of the potential for occupational overuse of the fingers." And agreed with Sauter et al. (1991, p.164) "...upper extremities are highly vulnerable .... wrist and hand in particular"

Lastly, as detailed in Chapter 4, Table 20, frequency of discomfort responses by body part was reduced by 70% over all, and was reduced by 57 to 87% per body part. The greatest reduction in frequency of discomfort response was found for the left shoulder (87%), the right upper arm (80%), the right forearm (75%), the left forearm (75%), and the neck (73%). Best reduction in frequency of discomfort results was seen after the introduction of all interventions (keyboard tray, ergonomic keyboard, web based training) during months 3 and 4 of the study.

Implications for Workplace Ergonomics

One important question investigated in the study was, Are the effects (initial financial and productivity costs) associated with the learning curve worth the eventual productivity increase and reduction in discomfort involved in the process, and if so, how long is the learning curve? Because the present experiment was performed in a real world office setting, the information derived from it may be especially transferable to daily work place applications and future studies.

When new products are introduced into the workplace, ergonomic practitioners may use the 2-week interval as the standard learning curve as opposed to guessing or using common sense. The fact that productivity improvements due to training on new products were most visible around the bi weekly intervals is relevant to everyday ergonomics in the workplace in a number of ways including, time management involved with scheduling proactive timelines and follow up visits. Based on the study results, it would not be a good idea to order a new product one week before a project due date even if the employee is stressed and experiencing repetitive strain symptoms. In addition, if a year end deadline or big project has a known timeline, it may be a good idea to audit the ergonomic workstations of the team involved and implement ergonomic training and products around 3-4 months and at minimum 3-4 weeks prior to the project start. In this regard, the present study results agree with Karlvist et al. (1994) and

Swanson et al. (1997) in that there is an initial decrease in productivity of new products followed by increased productivity and comfort once the learning curve has passed.

Another way the 2-week interval information is relevant to time management in the work place is in scheduling follow up visits. Scheduling a follow up visit during the first week may encourage the employee during the learning curve phase, while scheduling a follow up visit at the end of the second week may be better for measuring productivity and morale. The higher productivity of trained groups in the present study may indicate that in-person experience with a trained ergonomist increases productivity; this is important because companies may be able to make more informed decision regarding specialized ergonomic staffing. Because the training was a combination of in-person instructor and web based, it is difficult to differentiate the effects of in-person instructor versus web based training, but findings clearly suggest that both components working together effected positive results.

Another implication for the workplace is in the consideration of ergonomic products. In some instances the ANOVA results showed training was not the reason for increased productivity, thereby suggesting the keyboard tray and ergonomic keyboard were key factors that influenced the improved productivity scores throughout the study. The ergonomic interventions may have allowed for and afforded more neutral upper extremity postures and reduced static loading; which results agree with Sauter et al. (1991) and Nelson and Silverstein (1998) study findings.

Future Study Considerations

The fact that the present study provided discussion worthy and significant results primarily related to mouse use, rather than ergonomic keyboard use, lends to future exploration of the effects of training and keyboard trays on mouse use. The emphasis on mouse related results suggest a need for further study in future research. With the increase in mouse driven software brought about by the revival of Apple (MAC) Computers and Microsoft Windows drop and drag menus there is more of a need to investigate best mouse input methods than ever before.

Significant results were found with only 30 participants. Significant results may have been enhanced by the number of repeated measures raising the power of the study. Results may also have been enhanced by the benefits of using the transparent data collection software, online weekly survey, and weekly email reminders to participants to complete data. Both data tools took only a few minutes per week (~3-5) to complete and submit. Many participants specifically asked for a call and/or email reminder each week to assist in completion of the survey even though the data collection software had an automatic pop up reminder. For this particular population, the human element was very important regardless of the strength of technology.

Because the human element was so important, the Hawthorne Effect may have had an impact on the present study results (Mayo et al., 1933). In general the participant sample was motivated to participate in the study due to the possibility of improved comfort via the implementation of free ergonomic products (keyboard tray, ergonomic keyboard, and web based training), but the attention (in-person instructor training) the participants received along with the new products and training may also have motivated them to perform better at work.

Using the modern online surveys and data collection software allowed the Principle Investigator to work "smarter not harder." Because the use of modern online surveys and web based software allowed for a greater amount of quantitative and subjective data collection, and afforded an ease of data analysis heretofore unknown with traditional hard copy survey and data collection techniques, the Principle Investigator will be able to analyze the additional variables at leisure. Ideally, additional trends will be discovered and a greater amount of information will be available to share with the ergonomic community.

Lastly, because the ANOVAs did not show training as the cause of improved productivity with every variable, another interesting and valuable study design would be to look primarily at the differences in the effects of in-person instructor versus web based training. There has been general industry speculation about the effects of in-person instructor training compared to web based training. If web based training proved to be as or more effective than in-person, the current wave of injury management software programs could potentially eliminate ergonomic positions. The present study intentionally took an expansive approach and looked at the combination of both in-person instructor and web based training, but the comparison would provide for a very interesting future study.

Summary

The present study investigated the effects of ergonomic interventions (new products) and training on productivity and comfort, and found the following: 1) ergonomic intervention had a significant effect on productivity such that it contributed to increased productivity and decreased discomfort; 2) a combination of in-person instructor training and ergonomic web based training were effective in improving productivity and decreasing discomfort; 3) significant productivity and interaction results were found at all intervals over time, but most frequently at bi weekly intervals, which may indicate a 2-week learning curve on new products.

In summary, it appears that a combination of customized web based and in-person training (with an ergonomist); and workstation redesigns and ergonomic products (keyboard trays and ergonomic keyboards) used in the present study significantly improved computer productivity in the workplace. That is to say, using a combination of training and new products significantly increases productivity and may greatly reduce keyboard and mouse inputting discomfort levels. The present study relied upon the best research over the last two decades, and extended it by asking the question: How does training effect productivity on new ergonomic products? Answering the above question will add one more piece to the puzzle of global ergonomic knowledge, and help improve user productivity and in the workplace.

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APPENDIX A

STUDY OVERVIEW

UCSB Ergonomic Study Preparation Checklist

Pre Study Week 4: March 22-26

- Ergonomic team assigned 5-10 participants for duration of study
- Departmental IS Contacts coordinate download of RSIGuard with participant workstations and (using Training Checklist) train on:
  - RSI Guard and
  - UCSB EH&S Website online weekly evaluation survey

Study Begin - Study Week 1: March 29 – April 2nd

- First Day of Study March 29th
- First Participant online Weekly Evaluation April 2nd

Study Weekend Fri - Sun April 23, 24, 25

- April 23rd Humanscale trains Install Team on installations
- Install Team Installs 50 participant Keyboard Trays

Study Week 5: April 26th-27th (Optional)

- Ergonomic Team Trains 25 participants on keyboard tray adjustment

Study Week 9: May 24-25

- Ergonomic Team delivers ergonomic keyboards to 50 participants
- Trains 25 on keyboard installation and neutral wrist postures using Remedy Interactive, Stanford CD or OSHA Checklist (Method to be Determined).

Study Week 16: June 21-22 (potential RSIGuard addition)

- RSIGuard Team trains 25 on Stretch Break Capabilities

Study Week 21: July 19-23 (Optional)

- Ergonomic Team trains control group candidates on Keyboard Tray Adjustment, Keyboard Features, and Stretchbreak Capabilities

APPENDIX B

CONSENT FORM

Consent Form **Participant #________**

Agreement to Participate in Research

Responsible Investigator(s):______________________________________

Participant Name:____

Title of Protocol:____

1. I have been asked to participate in a 120 day research study investigating keyboard training and experience on productivity in the workplace.
2. I understand that completion of a pre-study demographic questionnaire prior to the beginning of the study is required and the answers to the questionnaire will determine whether I am eligible to participate in the study.
3. I will be asked to perform my daily work as usual.
4. No discernable risks to physiological or psychological health are expected.
5. Benefits to the subjects will include receipt of new ergonomic keyboard tray, keyboard, and productivity software product, as well as a better understanding of optimal workplace ergonomics and its effect on productivity.
6. There are no alternative procedures applicable.
7. The results of the present study may be published, but no information that could identify the subject will be included.
8. The first 45 subjects chosen will be compensated for participating in the present study with a Humanscale 2G Adjustable Keyboard Platform and mechanism, Kensington Comfort Keyboard, and RSIGuard Ergonomic Software. Any additional subjects (numbers 46+) will receive same keyboard platforms at 50% cost and keyboards and software for free.______

Participant initials above confirm review and understanding of page 1 of this consent form.

9. Any questions about this research may be directed to (Dawn Armstrong) the principal investigator at (805) 893-3283. Complaints about the research may be presented to the Committee Chair (Emily Wughalter) at (408) 924-3043. Questions about research, subjects' rights, or research-related injury may be presented to (Kathy Graham) Human Subjects Committee Reviewer, Office of Research at (805) 893-3807.
10. I understand that no service of any kind, to which the subject is otherwise entitled, will be lost or jeopardized if a person chooses to "not participate" in the study.
11. The procedures have been explained to me and I understand them. My consent is given voluntarily and I understand that I may refuse to participate in the study or in any part of the study. I also understand that if I do decide to participate in the study, or in any part of the study, I am free to withdraw at any time without prejudice from my relations to University of California, Santa Barbara or any other participating institutions.
12. I understand all personal information and data collected in relation to the present study will be treated with the utmost confidence and not passed on or confided to any party other than myself without my express permission.
13. I have received a signed and dated copy of the consent form.

The signature of a subject on this document indicates agreement to participate in the study. The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject has been fully informed of his or her rights.

Subject Signature Date

Researcher Signature Date

APPENDIX C

PRE EXPERIMENT PARTICIPANT DEMOGRAPHIC SURVEY

(Used with the Permission of Dr. Alan Hedge)

UCSB Pre-Study Survey

Please answer all question to the best of your ability.

Check answers by clicking on the appropriate selection, or filling in the field provided.

If you require additional space to respond to any of the items, please use the comments field in Question 26.

If you need assistance, please send email to: Dawn Langer

Please enter your name:
1) What is your age group in years? <24 25-34 35-44 45-54 55-64 >64
2) What is your gender? Male Female
3) How tall are you? --- feet --- inches
4) How would you describe your body build? Petite Small Medium Large Extra Large
5) Which is your dominant hand? Right Hand Left Hand Neither
6) How would you describe your touch typing ability? Beginner Intermediate Expert
7) What is your job title?
8) What is your Department?
9) How long have you worked at your current job? years months
10) How many years have you been doing this type of work? years
11) On average, how many hours per day do you use a computer? hours On average, how many days per week do you use a computer?

days

12) Of the total time spent using the computer, what percent of that time is spent: (a + b– c = 100%)

a) using the keyboard: %

b) using the mouse: %

a) using the keypad: %

14) How often in the day do you take rest/recovery breaks from typing/data entry tasks?

Never 1-2 times/day 3-4 times/day 5-6 times/day 7 or more times/day

15) How long is your average rest/recovery break?

minutes

16) How comfortable would you rate the following at work:

Keyboard	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable
Mouse	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable
Chair	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable
Desk/Work-surface	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable

17) Have you ever taken sick leave and/or disability leave because of computer work?

No Yes

If "Yes":

How many times has this happened? days

How long in total were you were out for all of the absence(s)? days

When was the most recent absence? (enter date MM/DD/YYYY)

18) Which of the following do you have at your workstation?

Keyboard tray	No	Yes
Ergonomic/split keyboard	No	Yes
Wrist rest	No	Yes
Ergonomic mouse	No	Yes
Ergonomic mouse mat	No	Yes
Footrest	No	Yes
Adjustable chair without armrests	No	Yes
Adjustable chair with armrests	No	Yes
Document holder	No	Yes
Anti-glare screen	No	Yes

19) Have you had your workstation assessed or adjusted by an ergonomist?

No Yes

If "Yes", when was this? (approx. date, enter as MM/DD/YYYY)

20) What type of corrective lens do you wear for computer work?

None Reading Glasses Regular Glasses Bifocals Trifocals Contact Lens Computer glasses

21) Do you have a personal computer at home?

No Yes

If "Yes":

Does it have an ergonomic split keyboard? No Yes

Does it have an ergonomic mouse? No Yes

Does it have an ergonomic keyboard tray? No Yes

22a) On average, how many hours per 24-hour period do you spend using your computer at home?

hours

22b) When using your home computer, what percent of that time is spent: (total should equal 100%)

Using the mouse? %

Using the keyboard? %

Using the keypad? %

23) In the past month have you been injured in any sport/recreational activity?

No Yes

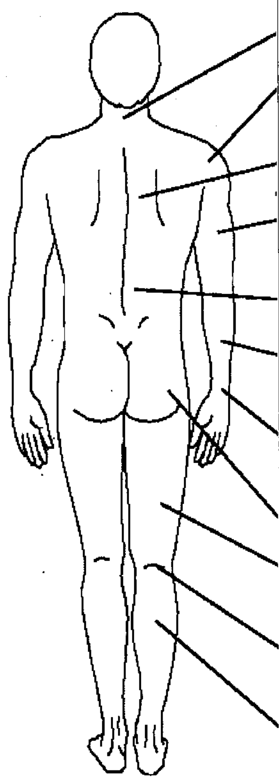
If "Yes", please describe:

24) Have you experienced any of the following eye symptoms while working at the computer?

Eyestrain, tired eyes	No	Yes
Sore, irritated eyes	No	Yes
Trouble focusing eyes	No	Yes
Teary, watery eyes	No	Yes
Dry, "gritty" eyes	No	Yes

25) Complete the following questions about any musculoskeletal discomfort associated with working at your computer.

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate boxes.



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	During the last 6 months, how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1-2 times per week	3-4 times per week	Several times each day	All day (8 hours)	Slightly uncom-fortable	Mod-erately uncom-fortable	Very uncom-fortable	Not at all	Slightly inter-fered	Sub-stantially inter-fered
Neck											
Shoulder (right)											
(left)											
Upper Back											
Upper Arm (right)											
(left)											
Lower Back											
Forearm (right)											
(left)											
Wrist (right)											
(left)											
Hip/Buttocks											
Thigh (right)											
(left)											
Knee (right)											
(left)											
Lower Leg (right)											
(left)											

26) Do you have any additional comments you'd like to add?

Submit Responses Now

APPENDIX D

ORAL DIRECTIONS TO SUBJECTS PRESENTATION

Effects of Keyboard Experience on Productivity and Comfort Participant Overview

Dawn Langer
Ergonomics Program Coordinator
UCSB

Introduction

- Over 50 billion dollars spent on direct and indirect workplace musculoskeletal injuries (OSHA, 2000)
- Increased # interfacing tools over last decade
    - alternatively designed keyboards
    - input devices
- Companies relying product design to
    - reduce discomfort
    - prevent injury

Poor Product Design Risks Injury

Dramatic increase in injuries over last 2 decades:

1. Epicondylitis
2. Carpal Tunnel syndrome
3. Repetitive strain disorders

Poor Product Design Risks Injury

Introducing new interfacing product may:

1. Reduce productivity (learning curve)
2. Increase risk of injury/discomfort
3. Increase company cost
   - (waste/insurance premiums)

Importance of Product Training

Question:

- "What impact does training have on comfort and productivity?"

***Reality*:**

- End users do not receive training or read instruction manuals

Importance of Study

- Extends body of ergonomic knowledge and research

Past Studies:

- focused on wrist postures, range of motion and discomfort

Current Study:

- focusing on the effect of training on productivity and discomfort

Problem Statement

- Keyboard design availability has increased accessory choices and reduced discomfort, but new products require training and experience to reap productivity benefits.
- Learning curve of unfamiliar product initially decreases productivity, but increases comfort.

2 Groups: 50 Subjects

Experimental Group	Trained	Untrained
Ergonomic Keyboard Tray	25	25
Ergonomic Keyboard	25	25

Methods

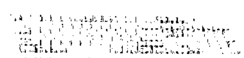
Medical History

- No reported injuries 3 years
- No symptoms 6 months

Tasks

- > 4 hrs./day Typing - Repetitive
- < 4 hrs./day Meetings and Phone Conferences

Methods

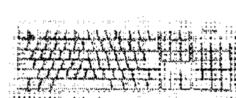


Apparatus

- RSIGuard Ergonomic Software

- Humanscale Keyboard Tray
- 0-15 degrees neg. tilt

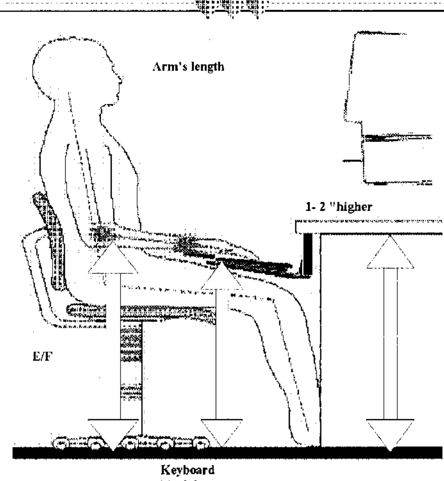
- Standard Qwerty Keyboard
- Kensington Comfort Keyboard
- 0 to 15 degrees splay



Methods

<u>Procedure</u>

1. Randomly selected participants
2. 50% male; 50% female
3. Initial Kick Off Meeting & Consent Form
4. All workstations adjusted post baseline
5. 30 day baseline productivity measurement
6. Weekly Productivity and Comfort Tracking



Methods

Duration

- 120 days; 2 Groups; n=25

Design

- Multi-Factorial, Between Subjects Study

Statistical Data

- Analysis of Variance

Innovative Research Questions....

1. Does the use of ergonomic keyboards result in greater user comfort, reduced injury, etc.?

2. If so, is the increase in comfort and decrease in injury associated with decreased productivity

3. To what do we attribute these findings?
   - Improved training?
   - Physiological effects of split keyboard design?
   - Both?

Next Steps....

This week (participant): Call Dawn if problem ASAP x3283

1. Check workstation for keyboard tray compatability
   - Workstation must be 28" from floor
   - No hanging lips or joints

Next week (participant)

1. Work with computer tech to download RSIGuard
2. First Online Weekly Evaluation Survey
   Friday, March 26th

Friday April 23 (Install Team)

1. Keyboard Tray Installation (ONLY DAY!)

Monday April 26, Remedy Interactive Online Training

1. Keyboard Tray Training

APPENDIX E

ONLINE WEEKLY EVALUATION

(Used with the Permission of Dr. Alan Hedge)

UCSB Weekly Evaluation Survey

Please answer all question to the best of your ability.

Check answers by clicking on the appropriate selection, or filling in the field provided.

If you require additional space to respond to any of the items, please use the comments field in Question 11.

If you need assistance, please send email to: Dawn Langer

Please enter your Study Identification Number:

Please select the Study Week Number:

---

1) For the past week, approximately how many hours of your work involved the use of a computer keyboard, mouse, or numeric keypad?

hours

2) For the past week, approximately what percent of total computer use time was spent using a mouse, keyboard, and/or numeric keypad?

Mouse	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
Keyboard	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
Keypad	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%

3) For the past week, how often in the day did you take rest/recovery breaks from typing/data entry tasks?

Never 1-2 Times 3-4 Times 5-6 Times 7- Times

4) If you took brief rest/recovery breaks during the day, how long was your average break?

minutes

5) For the past week, how comfortable would you rate the following at work?

Keyboard	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable
Mouse	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable
Chair	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable
Desk/Work-surface	Very comfortable	Moderately comfortable	Moderately uncomfortable	Very uncomfortable

6) In the past week have you taken any sick leave because of problems associated with your computer work?

No Yes

If "Yes", please describe:

7) If you are using the ergonomic keyboard tray, have you changed its settings (tilt and/or height) in the past week? If so, please record the new settings:

Tilt: degrees (negative) Height: inches

8) If you have used the ergonomic keyboard in the past week, approximately what percent of that time was spent using:

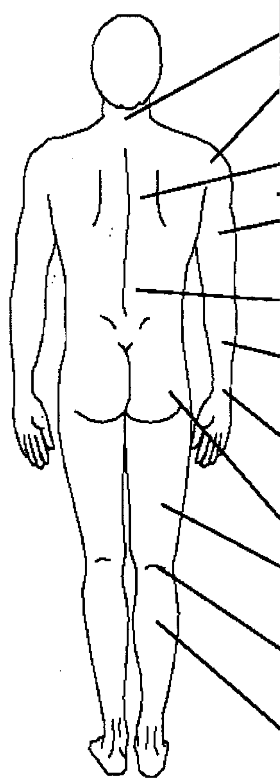
Neutral wrist posture	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
Traditional wrist posture	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%

9) If you have used the ergonomic keyboard in the past week, how has this affected your typing/data entey performance?

- No Effect
- Performance Greatly Improved
- Performance Moderately Improved
- Performance Moderately Worsened
- Performance Greatly Worsened

10) Complete the following questions about any musculoskeletal discomfort associated with working at your computer.

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate boxes.



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	During the last work week, how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1-2 times per week	3-4 times per week	Once each day	Several times each day	Slightly uncom-fortable	Mod-erately uncom-fortable	Very uncom-fortable	Not at all	Slightly inter-fered	Sub-stantially inter-fered
Neck											
Shoulder (right)											
(left)											
Upper Back											
Upper Arm (right)											
(left)											
Lower Back											
Forearm (right)											
(left)											
Wrist (right)											
(left)											
Hip/Buttocks											
Thigh (right)											
(left)											
Knee (right)											
(left)											
Lower Leg (right)											
(left)											

11) Do you have any additional comments you'd like to add?

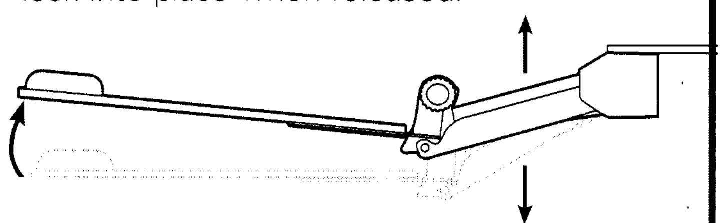
Submit Responses Now

APPENDIX F

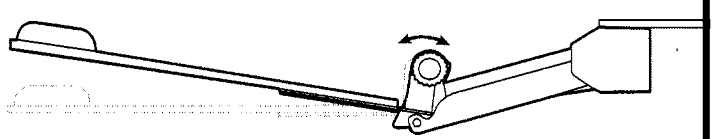
ERGONOMIC INTERVENTION GUIDES

2G ADJUSTMENT INSTRUCTIONS

To adjust platform height:
Lift front edge of keyboard and position at desired height. The platform will automatically lock into place when released.

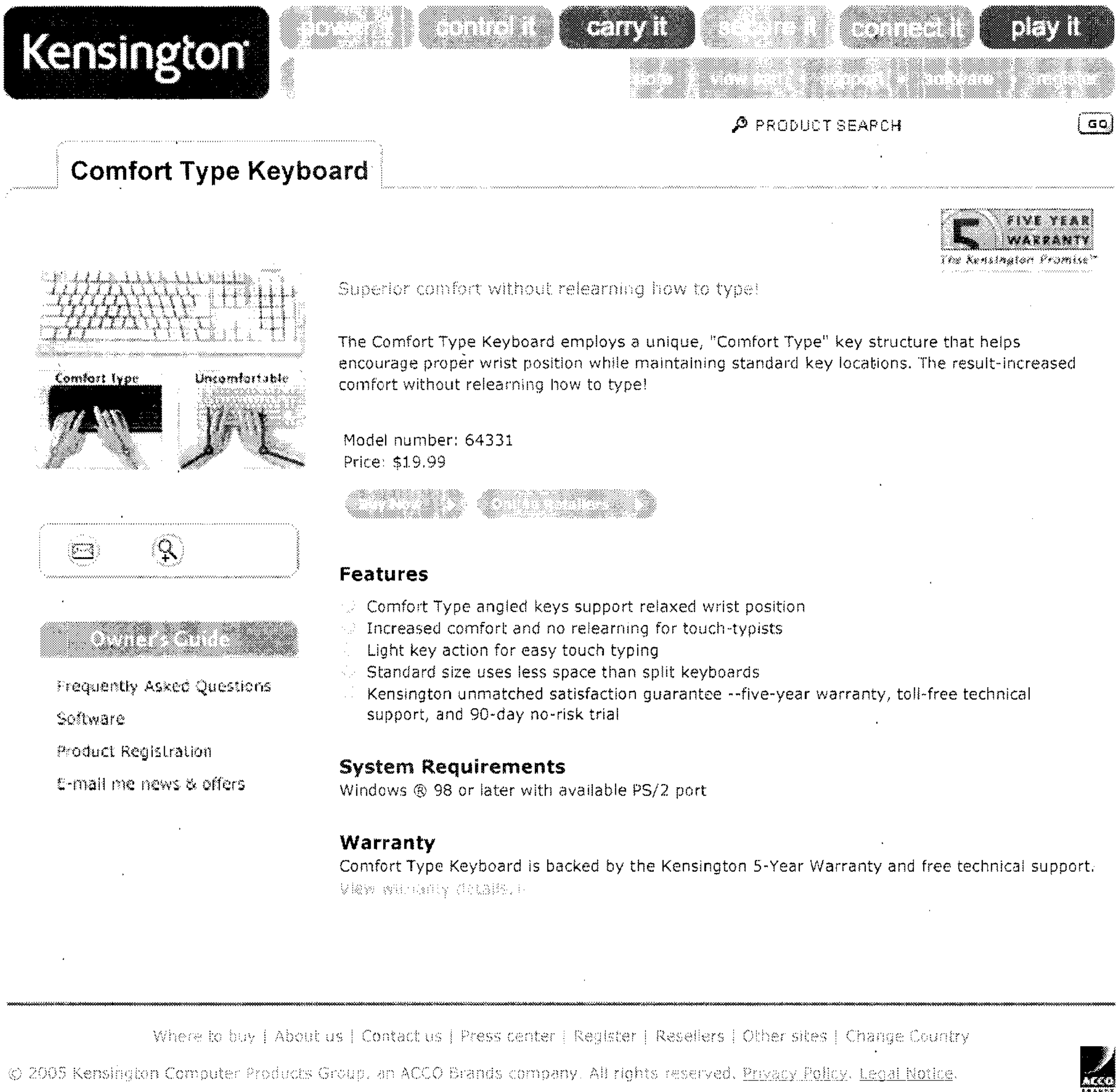


To adjust platform tilt:
Unscrew Angle Adjust Knob until loose. Adjust platform to desired tilt. Tighten Angle Adjust Knob.



Humanscale™ Creating a more comfortable place to work

Figure F1. Humanscale Corporation 2G Keyboard Platform Adjustment Guide


Kensington

carry it | play it

PRODUCT SEARCH GO

Comfort Type Keyboard

FIVE YEAR WARRANTY *The Kensington Promise™*

Comfort Type Uncomfortable

Superior comfort without relearning how to type!

The Comfort Type Keyboard employs a unique, "Comfort Type" key structure that helps encourage proper wrist position while maintaining standard key locations. The result-increased comfort without relearning how to type!

Model number: 64331
Price: $19.99

Owner's Guide

Frequently Asked Questions
Software
Product Registration
E-mail me news & offers

Features

- Comfort Type angled keys support relaxed wrist position
- Increased comfort and no relearning for touch-typists
- Light key action for easy touch typing
- Standard size uses less space than split keyboards
- Kensington unmatched satisfaction guarantee --five-year warranty, toll-free technical support, and 90-day no-risk trial

System Requirements

Windows ® 98 or later with available PS/2 port

Warranty

Comfort Type Keyboard is backed by the Kensington 5-Year Warranty and free technical support.

Where to buy | About us | Contact us | Press center | Register | Resellers | Other sites | Change Country

© 2005 Kensington Computer Products Group, an ACCO Brands company. All rights reserved. Privacy Policy. Legal Notice.

Figure F2. Kensington Ergonomic Products, Inc. Comfort Type Keyboard Features Guide

UCSB Ergonomic Study
RSIGuard Installation instructions

Study Participants should have RSIGuard software installed at the beginning of the study.

- Some RSIGuard features will be turned <u>off</u> for the study, including:
  - Autoclick
  - BreakTimer and Stretches
  - ForgetMeNots
  - KeyControl and RSIScripts

- RSIGuard features that will be turned <u>on</u> include:
  - DataLogger
  - Health Status Reports

- After you have installed RSIGuard, you can always check to see what components are installed or not by using the Tools and Settings menus of RSIGuard.

- Register the software so that the software does not expire using the research code _________.

Questions? Call Dawn Langer at (805) 893-3283

Figure F3.. Remedy Interactive, Inc.'s RSIGuard 3.0 Installation Guide

APPENDIX G

RSIGUARD 3.0 USER'S GUIDE & DATA LOGGER INFORMATION

(Provided by Remedy Interactive, Inc. via website: http://www.rsiguard.com)

RSIGUARD 3.0 USER'S GUIDE

RSIGuard installation is easy.

To start, if you already have a previous version of RSIGuard installed, you do not need to uninstall it first. If you have already registered RSIGuard, new versions will be automatically registered (however, if you download RSIGuard Stretch Edition, the stretches will only be available for 45 days since they require a purchased upgrade).

Download RSIGuard from the internet, or, insert the CD if you have an RSIGuard Installation CD. If your browser allows you to "Run this program from it's current location," you may wish to do that. If not, then after downloading and saving the installation program (e.g., to your Desktop), run the downloaded program, and follow the instructions.

RSIGuard uses InstallShield, so you can easily uninstall RSIGuard if desired. To do so, click on the Start button, click on Programs, then click on RSIGuard, and select the "Uninstall RSIGuard" item. Optionally, you can click the Start button and select "Settings" and then "Control Panel." Double click on "Add/Remove Programs." Select "RSIGuard" in the list of items shown, and click on "Add/Remove." RSIGuard will be uninstalled.

RSIGuard's main display gives you easy access to each of the program's main features.

The Tools, Setup, and Help menu items give you access to all of RSIGuard's features. The buttons from left to right allow you to enable or disable various RSIGuard features. You can also enable or disable features from the Settings dialog in the Setup menu, but the main display buttons allow you to do it very quickly.

- This button allows you to enable/disable the BreakTimer feature. When in the down position (as shown), the feature is enabled.

- This button allows you to enable/disable the ForgetMeNots feature.

- This button allows you to enable/disable the AutoClick feature.

The trauma bars for Typing and Mousing show how much trauma you have accumulated at any moment from keyboard and mouse usage. The bars increase during keyboard and mouse use and decrease during periods of rest/breaks. A thin line appears underneath the word Typing or Mousing when RSIGuard considers you to be typing or mousing. To hide these trauma bars, visit the Main Display Options in the Tools menu.

Below the trauma bars are worktime statistics (updated every few seconds). "Last-Break" tells you how long it has been since your last break. "Next-Break" estimates how long it will be until your next break (the value accounts for average trauma, postponed breaks, min & max time between breaks, etc.). The third time statistic will be either "Time@Work" or "Work Limit." "Time@work" tells you how long you have been working at the computer. "Work Limit" will be shown only if you have defined a work restriction in the BreakTimer setup. In this case, "Work Limit" informs you how long you have to work before reaching your work limit. To hide these time statistics, visit the Main Display Options in the Tools menu. For more information about RSIGuard features, view the help items on the main help page.

View Usage Statistics

Under the "View Usage Statistics" item there are 3 choices:

"View Longterm Usage Statistics" will launch the "RSIGuard Reports" utility to view your longterm computer usage statistics.

"View Today's Usage Statistics" let's you see statistics that reflect how you are working to today and shows today's work intensity compared to your average.

"View Keyboard Analysis Tool" lets you see which keys you use most frequently, how long you hold keys down, and how long it takes you to find each key.

Along with other information, this information may be useful in selecting an ergonomic keyboard.

Submit a Health Status Report

This item lets you create and submit a Health Status Report. Unless your employer has configured this feature to submit your report via a network to an ergonomics coordinator, your report will only be stored locally on your computer. Click here for more information about Health Status Reports.

Take A Break Now

This menu item allows you to start a break early. If you know you are about to take a break, selecting this item (or pressing the "Take A Break Now" hotkey) will cause a break to start now, giving you trauma credit that will let you work longer later.

The Main Display Options

Under the "Health Status Reports" item there are 5 choices:

1) "Show Trauma Bars" - The trauma bars indicate how much trauma you have accumulated from mousing and typing. You can choose to have them visible or not in the main display with this option.

2) "Show WorkTime Statistics" - The time statistics show time since last break, time to next break, and total time worked today (or time left to work if Work Restriction is enabled). You can choose to have these times appear or not in the main display with this option.

3) "Automatically Hide Main Control Buttons" - If this option is selected, the main RSIGuard window will automatically shrink when the mouse moves away from RSIGuard and reexpand when the mouse passes over the window again.

4) "Hide RSIGuard (Icon in System Tray remains)" - This option will make the RSIGuard window invisible and remove it from the task bar. The RSIGuard icon remains in the system tray, and clicking on it restores the RSIGuard window.

5) "Keep RSIGuard Always On Top" - If selected, the RSIGuard main display window will always remain visible atop normal windows.

Run an RSIScript

Lets you run an RSIScript from your local computer, from the web, or a script associated with a registration code. Scripts can also be associated with hotkeys in the KeyControl settings screen. Click here for more information about RSIScripts.

Schedule Regular Health Status Reports

Allows you to request that on a regular schedule, RSIGuard will remind you to complete a Health Status Report survey. Click here for more information about Health Status Reports.

Exit RSIGuard

This will exit RSIGuard (stopping all RSIGuard features from functioning until RSIGuard is run again).

Setup Menu Items

The setup menu of the main RSIGuard window.

Purchase & Register RSIGuard

If your copy of RSIGuard is not registered, this item will appear to let you enter your registration code or visit the RSIGuard website to purchase one. This item will not be visible if you have a registered copy of RSIGuard.

Settings

This option lets you personalize various features of RSIGuard. The tabs of the Settings dialog are explained in the documentation for the corresponding features: BreakTimer; Stretch Break (RSIGuard Stretch Edition only), ForgetMeNots; AutoClick, KeyControl. The Personalization tab lets you define certain aspects of how you work and your work environment which RSIGuard can use to customize its behavior. An Admin tab is available only if you are an RSIGuard administrator (generally available only to site license holders).

Run Setup Wizard

When a new user profile is created, the Setup Wizard lets the new user enter some basic initial settings. You can run the wizard again in the future, but generally it makes more sense to use the Settings (described above) since Settings lets you customize RSIGuard more than the Wizard does.

Show Hotkey Assignments

This feature will launch a Notepad session with a file that contains all the RSIGuard hotkey assignments you have made. This allows you to either view or print your hotkeys.

Profile Management

Under the "Profile Management" item there are 4 items:

"Select User" - This lets you select a particular one of your configuration profiles. You may wish to have multiple profiles, for example, if at different times of the month your work tasks are very different.

"Add User" - Select this option to create an additional configuration profile for your Windows user login. This allows you to have multiple distinct groups of settings for each Windows user.

"Remove User" - Select this option to remove a configuration profile from your Windows user login when it is no longer in use.

"Manage Roaming Profile" - Select this option to manage the network aspects of a roaming profile. Roaming Profiles is a feature that lets you store configuration profiles on a network. That way, when you log in from a different computer (with the same Windows login ID) your profile will move around with you. If you use a portable that isn't always connected to the network (or if your desktop becomes detached from the network), RSIGuard will use the profile that was available the last time the portable (or desktop computer) was connected to the network.

In this window, you specify the network folders where the configuration is to be stored. You can also optionally change where the DataLogger data is stored.

Help Menu Items

The help menu of the main RSIGuard window.

Online RSIGuard Help

This menu item takes you to the online help system you are currently viewing. This feature requires access to the internet.

ErgoHints

This menu item shows you ergonomic tips for using a computer (from Para Technologies).

Check for RSIGuard Upgrade

This item informs you whether the version of RSIGuard you are running is up to date, or if a new version is available. This feature requires access to the internet.

About RSIGuard

This item informs you of:

the version of RSIGuard you are running

your registration status

your RSIGuard ID#

the main features of RSIGuard

RSIGUARD 3.0 DATA LOGGER INFORMATION

DataLogger Detailed Analysis.

- Time Spent at Computer -- Shows how many hours during your workday are spent at the computer and away from the computer
- Strain from Using Keyboard -- Based on a study of strain associated with different keyboard actions (e.g.,pressing 'A' vs. 'G', pressing 'P' vs. 'Ctrl P', etc.), this statistic estimates your exposure to muscle strain. This measurement gives a relative measure of strain exposure between your exposure at various different points in time or between various different people. However, there are no established thresholds of safe or unsafe exposure.
- Strain from Using Mouse -- Based on a study of strain associated with different mouse actions (e.g.,single click vs. double click, drag and drop operations, etc.), this statistic estimates your exposure to muscle strain. This measurement gives a relative measure of strain exposure between your exposure at various different points in time or between various different people. However, there are no established thresholds of safe or unsafe exposure.
- Start & End Time at Computer -- Shows the starting and ending times of your daily computer use.
- BreakTimer Breaks Taken & Skipped -- Shows how many BreakTimer-suggested breaks you took and how many you skipped.
- Microbreaks Taken & Skipped -- Shows how many Microbreaks you took and how many you ignored.
- Natural Breaks Taken -- Shows how many natural rests you take while using the computer. Four different lengths of natural rest breaks are measured and displayed.
- Time in BreakTimer Breaks -- Shows how many minutes you spend in BreakTimer-suggested breaks.
- Minutes Breaks Postponed -- Shows how many minutes you put off taking BreakTimer-suggested breaks via the "Postpone Break" buttons.
- Stretches Viewed -- Shows how many stretches were displayed to you during BreakTimer-suggested breaks.
- Keypress Force Estimate -- Shows an estimate of how hard you struck keys during the day based on a model that measures force by watching how long keys are held down.

- Keypresses -- Shows how many keypresses you made during each day
- Keystrike pressure by key -- Shows an estimate of how hard you strike each key on the keyboard based on a model that measure the length of time you hold each key down.
- AutoClicks -- Shows how many Mouse Clicks you avoided needing to do by using AutoClick.
- Manual & KeyControl Drag & Drops -- Shows how many times you performed drag & drop operations using the mouse, and how many times you performed drag & drop operations using KeyControl
- Hours using Keyboard & Mouse -- Shows how many hours are spent using the keyboard and the mouse individually. Note that the sum of these two numbers do not equal time spent at the computer because you often use the keyboard and mouse at the same time.
- Words Typed -- Shows how many words you typed while using the computer.
- Keystroke frequency by key -- Shows how much you use each key on the keyboard. Usage is expressed as a percentage of total keypressing.
- Typing Corrections -- Shows how many times you pressed sequences of Delete or Back-space keys. These can be an indication of how many errors a user is making (assuming the user's job is not, for example, copy editing).
- Total Mouse Distance Movement -- Shows an estimate of how much mouse movement you performed each day.
- Mouse Clicks -- Shows how many Mouse Clicks you perform each day.
- Switches between Keyboard & Mouse -- Shows how many times you switched from (i.e. moved your arm between) the mouse to the keyboard or vice-versa.

APPENDIX H

DETAILED TRAINING PLAN

Training and Set-Up Plan

Training and set-up for the present study will take place in three separate stages, as described below. The purposes of these activities are as follows: 1) select individuals for possible participation in the study, 2) provide oral briefings to individuals selected as participants, 3) provide participants with the opportunity to ask questions about the study, 4) install equipment in participants' workspaces, and 5) provide instruction on the use of the equipment. Specifically, training and set up will occur in three stages at each site where data collection will occur. All training will be provided by professional ergonomists and will include the aspects described on the Individual Training and Set Up Check List following. Training will not be consider complete until the employee has demonstrated capability and understanding of each aspect on the Check List.

Stage 1

The primary activity during Stage 1 will be to distribute a pre-experiment questionnaire to a group consisting of all employees at a given site who have indicated an interest in possibly participating in the present study (Appendices D-E). The purpose of this questionnaire will be to identify which of these employees will be asked to participate in the study (based on factors such as presence or absence of upper body WMSD symptoms, gender, age, etc.). An oral briefing will be given to employees (preferably in one large group, though realistically it may be necessary to brief several smaller groups within each individual site) explaining the purposes of the study, as well as specific instructions for filling out the pre-experiment questionnaire (Appendix B). Employees will be asked to fill out the questionnaire in private. The questionnaire should be able to be accessed as an electronic document or as a document located on a restricted access website. Stage 1 should occur approximately one month before Stage 2 to allow enough time to analyze the pre-experiment questionnaire data and make randomized group/condition assignments for the study (Appendix A).

Stage 2

Stage 2 will consist primarily of baseline data collection; that is, collection of keyboard productivity and comfort data prior to the introduction of any of the planned experimental manipulations. However, to collect these data we will need to install RSIGuard (to collect productivity data) and we will also need to brief participants on how to fill out their on-line weekly keyboard comfort questionnaire (Appendix E).

Stage 2 will need to be initiated approximately one-month prior to the start of Stage 3.

Stage 3

Stage 3 training and set up will involve briefing participants on the characteristics of the new equipment they will be using, as well as training on how to use it (Appendix H, Figures 1-5). This will involve individual set up and instruction at individual work sites by ergonomists. Instruction will be provided in detail to training test groups and will include installation and adjustment of ergonomic product interventions, as well as, special functions based on the manufacturer's User's Guides included in the packaging (Appendix G).

Training and Workstation Set-Up Check List

All Participants – Study Introduction
(each task below must be completed before Subject can participate in study)

- ❑ Subject attended Participant Overview Meeting on
  Date:______________
- ❑ Subject completed and Instructor has a
  signed original Consent Form
- ❑ Subject completed and Instructor has an original of
  Participant Demographic Questionnaire
- ❑ Subject completed and Instructor has a copy of
  Participant Discomfort Survey
- ❑ Instructor familiarize Participant with
  Online Weekly Evaluation Survey (WES)
- ❑ Ensure Participant comfortable with Online WES by having
  them demonstrate completion of WES.

All Participants - Workstation Adjustment and Ergonomic Basics
(each task must be completed before Subject can participate in study)

- ❑ View Figure H1 Workstation Guidelines
- ❑ Ensure participant understands how to physically adjust all
  workstation furniture including
    - Chair
    - Keyboard Tray
    - Mouse Platform
    - Footrest (if applicable)
- ❑ View Figure H5 Anthropometry
- ❑ Instructor take Subject anthropometric measurements including:
  (measurements must be taken *after* chair is appropriately adjusted)
    - Popliteal distance to floor
    - Elbow distance to floor
    - Eyes distance to monitor

- ❑ Ensure Participant understands individual anthropometric measurements by changing workstation around and having participant readjust to individual anthropometry.

- ❑ View Figure H4 Wrist Posture

- ❑ Instructor train participants in neutral wrist postures and whole arm movements.

- ❑ Ensure Participant understand neutral wrist postures and whole arm movements by having participant demonstrate.

- ❑ Install RSIGuard 3.0 on participant computer.

- ❑ Explain purpose and ensure participant does not need to interact with RSIGuard.

- ❑ Deliver packaged Kensington ergonomic keyboard.

Trained Groups Only – Ergonomic Keyboard Training
(each task must be completed before Subject can participate in study)

- ❑ If Subject in Trained Group, instructor familiarize participant with Ergonomic Keyboard User's Guide

- ❑ Allow *Participant* to install keyboard. Instructor to assist if necessary.

- ❑ Instructor train Subject in the following Specialized keyboard functions:
  - Horizontal wrist splay 0-30 degrees
  - Vertical wrist pronation 0-30 degrees
  - Imbedded number pad
  - Editing key layout for right and left work distribution

Participant # (please print clearly)	Signature and Date
Instructor Name (please print)	Signature and Date

UCSB Ergonomic Study
How to Adjust Your Keyboard Tray

2G ADJUSTMENT INSTRUCTIONS

To adjust platform height:

- Lift front edge of keyboard and position at desired height.
- The platform will automatically lock into place when released

To adjust platform tilt:

- Unscrew Angle Adjust Knob until loose.
- Adjust platform to desired tilt. Tighten Angle Adjust Knob.

Trainer Checklist:

- ❑ Introduce self to participant
- ❑ Handout 2G instruction page
- ❑ Review appropriate keyboarding height
- ❑ Review reasoning for platform tilt
- ❑ Demonstrate 2 adjustments
- ❑ Ask participant to demonstrate adjustments until proficient using Participant Proficiency Checklist to right.

If you have any problems adjusting your keyboard tray, please contact Dawn Langer at *(805) 893-3283* or Email: dawn.langer@ehs.ucsb.edu

Participant #:_____ Date:___________

Participant Proficiency Checklist

- ❑ Step One: Center the platform with your monitor and documents.
- ❑ Step Two: Adjust the Height of the keyboard tray by lifting the edge of the platform closest to you. Position the platform at your ideal keying height (one inch lower than your elbows). **Note**: In addition, the platform can move side to side and can be pushed completely under the work surface (except with 17" tracks).
- ❑ Step Three: Place your keyboard centered on the platform and your mouse on the adjacent surface to the left or right of the keyboard tray.
- ❑ Step Four: Adjust the tilt of keyboard tray by turning the round mechanism on the keyboard track towards you. This loosens the in mechanism, allowing it to move freely in a negative or positive tilt. Next, adjust the platform to the desired tilt and then tighten the mechanism.
Note: If you prefer to sit upright, it is more beneficial to position the platform in a negative tilt. However, if you are not a "touch typist" or if you prefer to sit in a "reclined" position, it may be more comfortable to position the platform in a flat or positive tilt.

Workstation

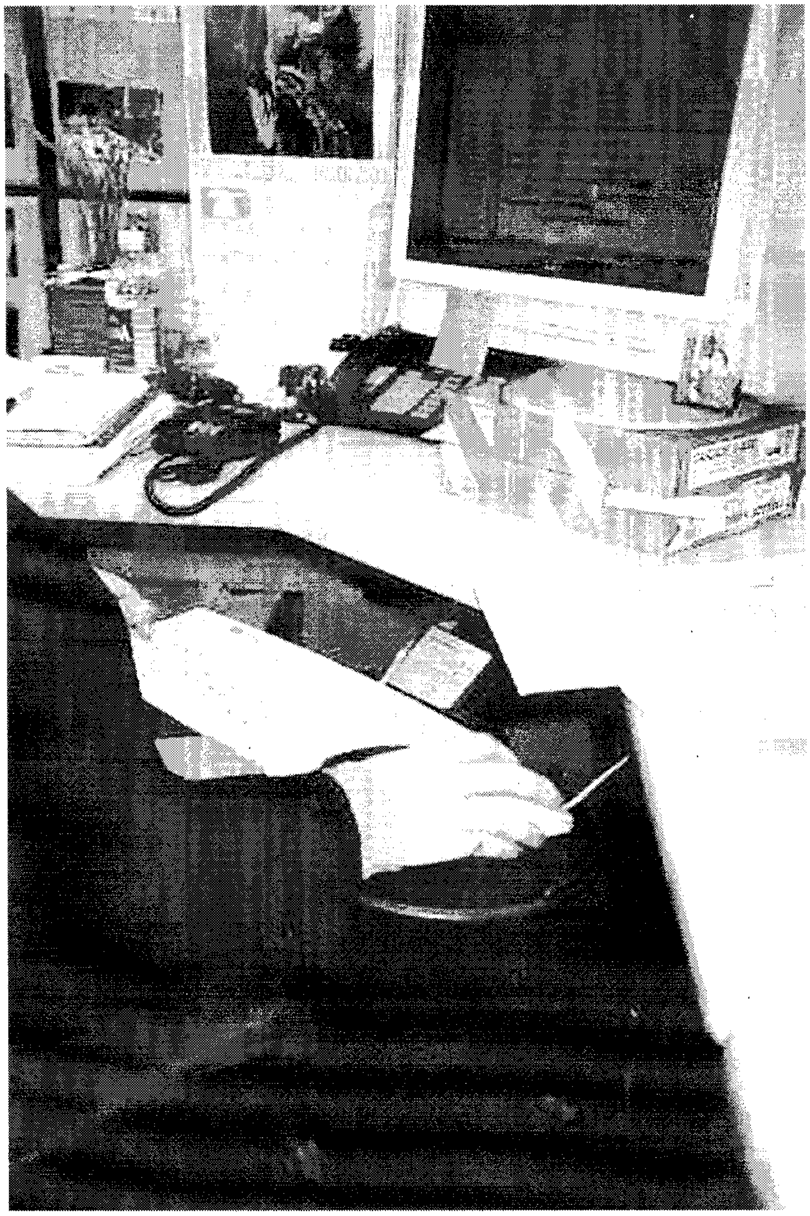


Figure H1. Workstation includes Humanscale keyboard trays (picture provided by America Online, Inc.)

Standard keyboard and Kensington ergonomic keyboard

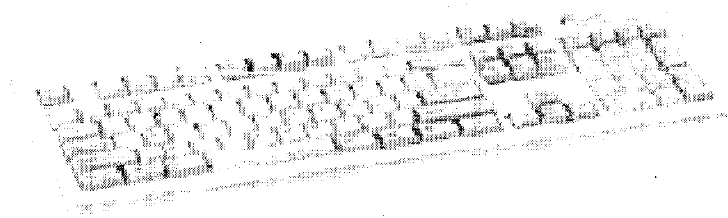


Figure H2. Standard keyboard issued with purchase of most personal computers (picture provided by AOL, Inc.)

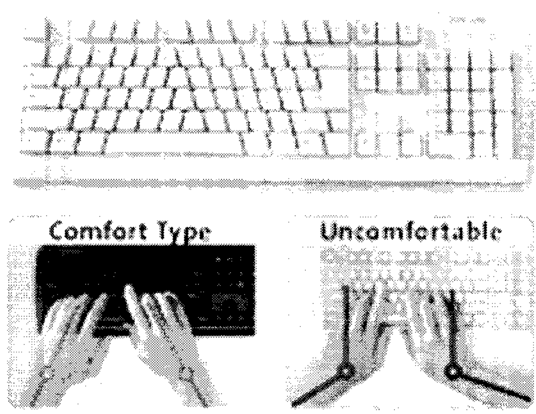


Figure H3. Kensington Comfort keyboard features splay options to allow neutral wrists (picture provided by Kensington Ergonomic Products, Inc. public website).

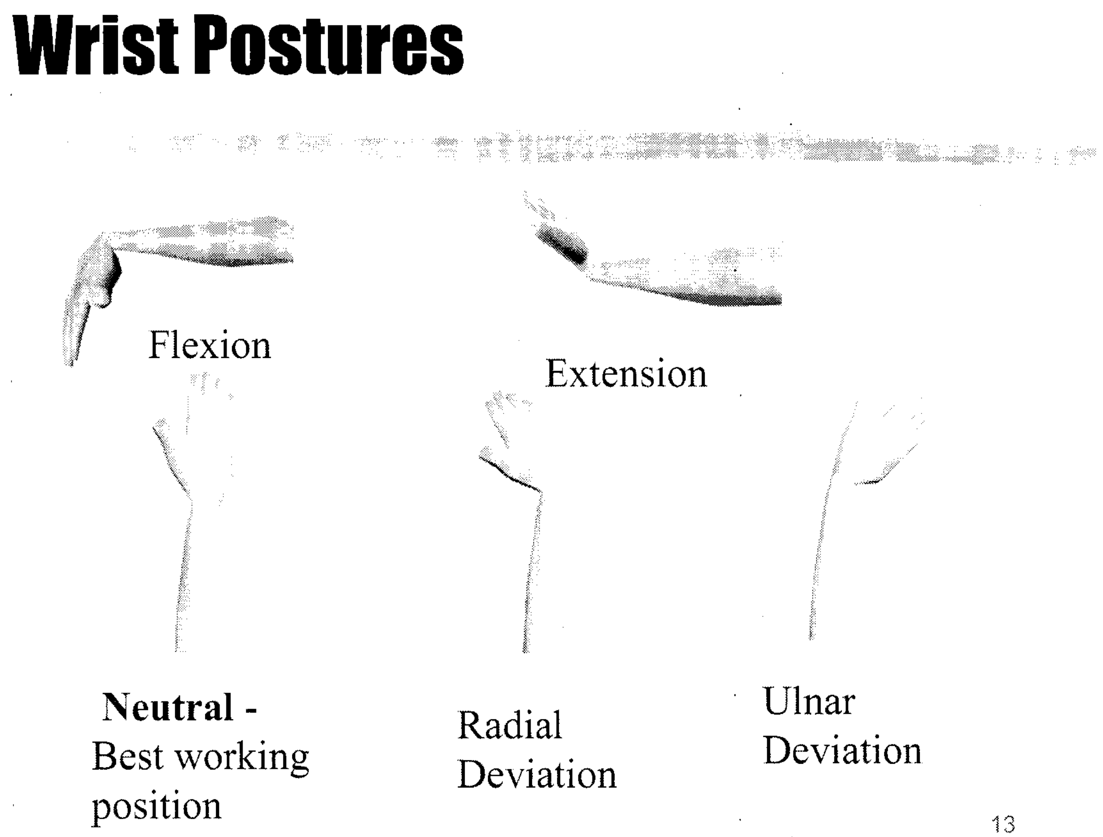


Figure H4. Non-Neutral Wrist Postures increase risk of ergonomic injury and are often afforded by poor computer accessory product design (picture provided by EORM, Inc.).

Anthropometry

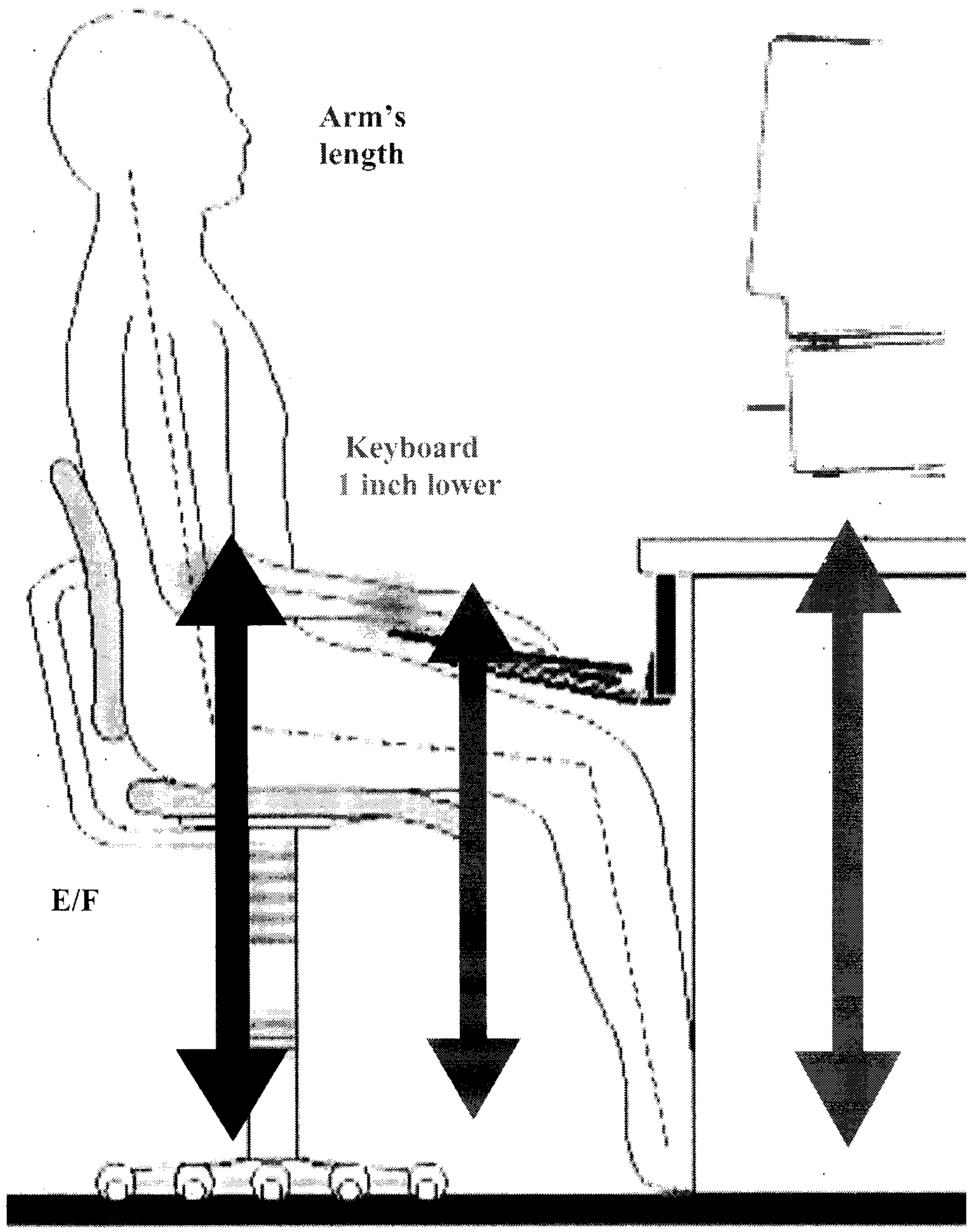


Figure H5. Definition: the measurement of physical proportion as it relates to the design of systems that are compatible with the constraints of the human body

(picture provided by America Online, Inc.)

APPENDIX I

ADDITIONAL PRODUCTIVITY DATA TABLES

Table I1

Summary of ANOVA Productivity Data for Mouse/Keyboard Switches (Pre versus Post)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Training	1042637740.02	1	1042637740.02	4.28	.051*
Error	5361261898.96	22	243693722.68		
Months	114920446.69	1	114920446.69	3.02	.096
Months*Training	98771063.02	1	98771063.02	2.60	.121
Error(months)	837482519.79	22	38067387.26		

*p < 0.05

Table I2

Summary of ANOVA Productivity Data for Total Mouse Distance (Pre versus Post)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Training	6188201617963.01	1	6188201617963.01	4.02	.058**
Error	33908539994629.28	22	1541297272483.15		
Months	335823132040.02	1	335823132040.02	3.24	.086
Months*Training	134864968015.02	1	134864968015.02	1.30	.267
Error(months)	2283527916947.46	22	103796723497.61		

**p < 1.0

Table I3

Summary of ANOVA Productivity Data for Mouse/Keyboard Switches (Monthly)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Training	1842350697.04	1	1842350697.04	4.18	.053*
Error	9702104324.92	22	441004742.04		
Months	174201170.21	3	58067056.74	.73	.535
Months*Training	247589620.04	3	82529873.35	1.04	.379
Error(months)	5220866021.75	66	79104030.64		

*p < 0.05

Table I4

Summary of ANOVA Productivity Total Mouse Distance (Monthly)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Training	9897110554536.25	1	9897110554536.25	4.27	.051*
Error	50980539805899.70	22	2317297263904.53		
Months	917528880216.03	3	305842960072.01	2.60	.059**
Months*Training	284160384600.87	3	94720128200.29	.81	.495
Error(months)	7763353476058.85	66	117626567819.07		

*p < 0.05, **p < 0.10

Table I5

Summary of ANOVA Productivity Total Mouse Distance (Weekly)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Training	772508870843.47	1	772508870843.47	1.92	.193
Error	4423773416831.05	11	402161219711.91		
Weeks	496210174824.21	17	29188833813.19	1.88	.022*
Weeks*training	408860619136.36	17	24050624655.08	1.55	.081
Error(weeks)	2899122473024.72	187	15503328732.75		

*p < 0.05

Table I6

Descriptive Productivity Keyboard Word Count Statistics Collapsed Over Groups (2-week intervals)

Training	Mean	N	Std. Deviation
Trained	110634.52	9	42633.59
Untrained	86549.78	12	43632.25
Total	96871.81	21	43855.29

Table I7

Descriptive Productivity Mouse/Keyboard Switches Statistics Collapsed Over Groups (2-week intervals)

Training	Mean	N	Std. Deviation
Trained	489422.06	9	142770.98
Untrained	458089.71	10	210119.22
Total	472931.35	19	177179.98

Table I8

Descriptive Productivity Total Mouse Distance Statistics Collapsed Over Groups (2-week intervals)

Training	Mean	N	Std. Deviation
Trained	1631336.81	9	664646.10
Untrained	1069998.90	10	466384.86
Total	1335895.81	19	622907.57

Table I9

Descriptive Productivity Mouse Work Seconds Statistics Collapsed Over Groups (2-week intervals)

Training	Mean	N	Std. Deviation
Trained	4417629.29	9	2242639.63
Untrained	2875731.09	10	1273897.18
Total	3606103.92	19	1916338.99

Table I10

Descriptive Productivity Mouse Clicks Statistics Collapsed Over Groups (2-week intervals)

Training	Mean	N	Std. Deviation
Trained	3208513.74	9	2132935.52
Untrained	2191750.49	10	905885.63
Total	2673375.19	19	1644484.95

Table I11

Descriptive Productivity Mouse Click Statistics Collapsed Over Groups (Pre versus Post)

Training	Mean	N	Std. Deviation
Trained	53928.67	12	30624.62
Untrained	36349.33	12	18995.89
Total	45139.00	24	26490.38

Table I12

Descriptive Productivity Mouse/Keyboard Switches Statistics Collapsed Over Groups (Pre versus Post)

Training	Mean	N	Std. Deviation
Trained	27154.42	12	19107.31
Untrained	14606.96	12	10131.48
Total	20880.69	24	16271.78

Table I13

Descriptive Productivity Total Mouse Distance Statistics Collapsed Over Groups (Pre versus Post)

Training	Mean	N	Std. Deviation
Trained	2446497.46	12	1603128.10
Untrained	1422337.38	12	816242.21
Total	1934417.42	24	1349595.83

Table I14

Descriptive Productivity Mouse/Keyboard Switches Statistics Collapsed Over Groups (Monthly)

Training	Mean	N	Std. Deviation
Trained	60918.00	12	40656.15
Untrained	35014.52	12	24414.06
Total	47966.26	24	35364.32

Table I15

Descriptive Productivity Total Mouse Distance Statistics Collapsed Over Groups (Monthly)

Training	Mean	N	Std. Deviation
Trained	4887181.06	12	2934073.15
Untrained	2936602.48	12	1546221.04
Total	3911891.77	24	2500643.16

Table I16

Descriptive Productivity Total Mouse Distance Statistics Collapsed Over Groups (Weekly)

Training	Mean	N	Std. Deviation
Trained	5976164.48	6	3011054.44
Untrained	4086790.04	7	1997295.76
Total	4958809.01	13	2594872.81

APPENDIX J

COMFORT DATA BY BODY PART

Figures J1 through J11 are a comparison of trained vs. untrained groups and indicated a general reduction in discomfort after the introduction of each variable (keyboard, keyboard tray, software training) over time.

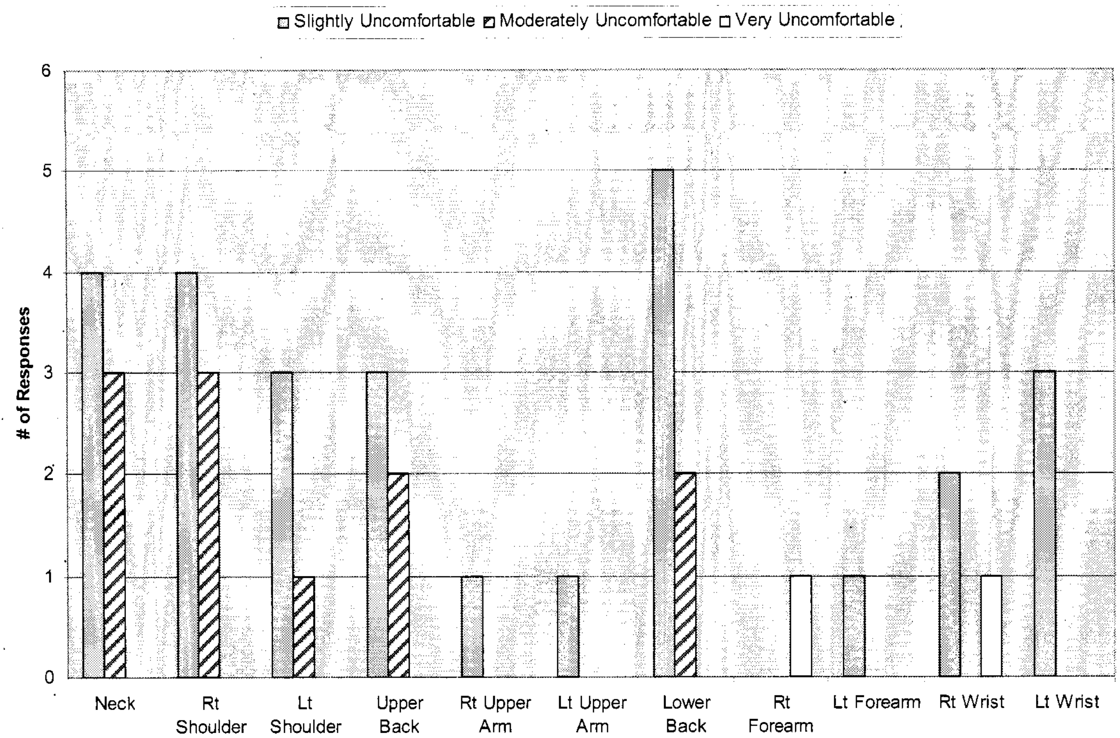


Figure J1. Graph of Trained Group Pre Study Discomfort Levels by Body Part indicating the highest frequency of responses in the lower back, neck, and right shoulder; and the highest severity of responses in the right forearm and right wrist.

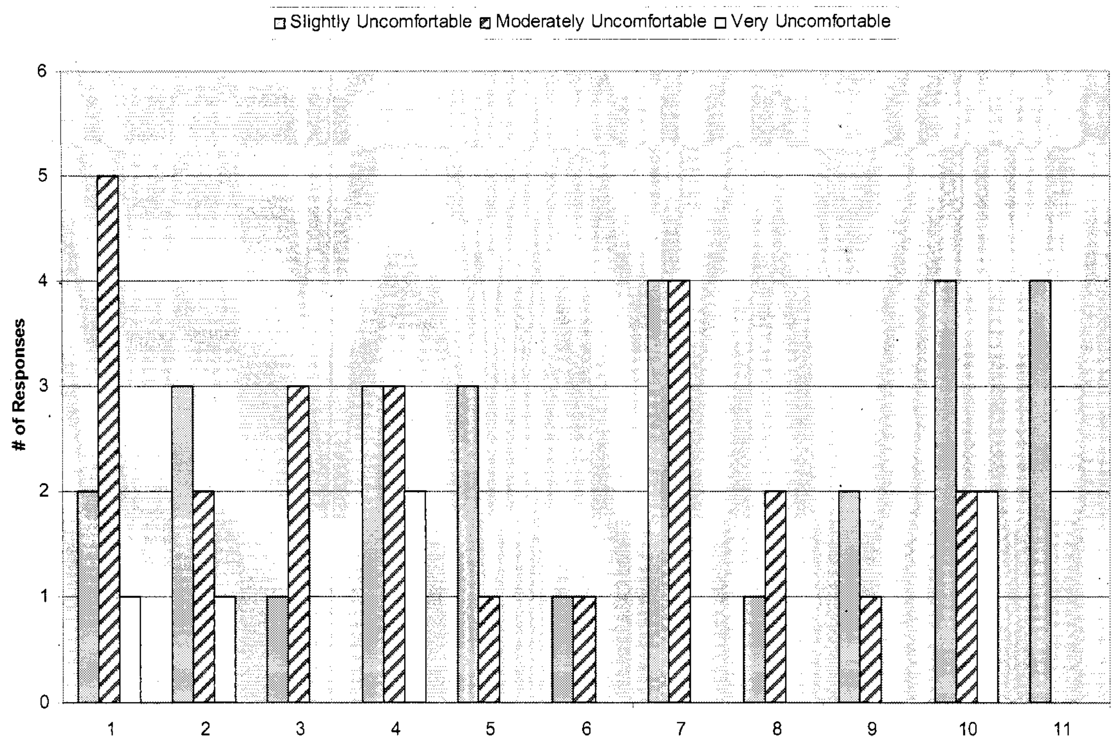


Figure J2. Graph of Untrained Group Pre Study Discomfort Levels by Body Part indicating highest frequency of responses in the neck, lower back right, and left wrists; and the highest severity of responses in the upper back, right wrist, neck, and right shoulder.

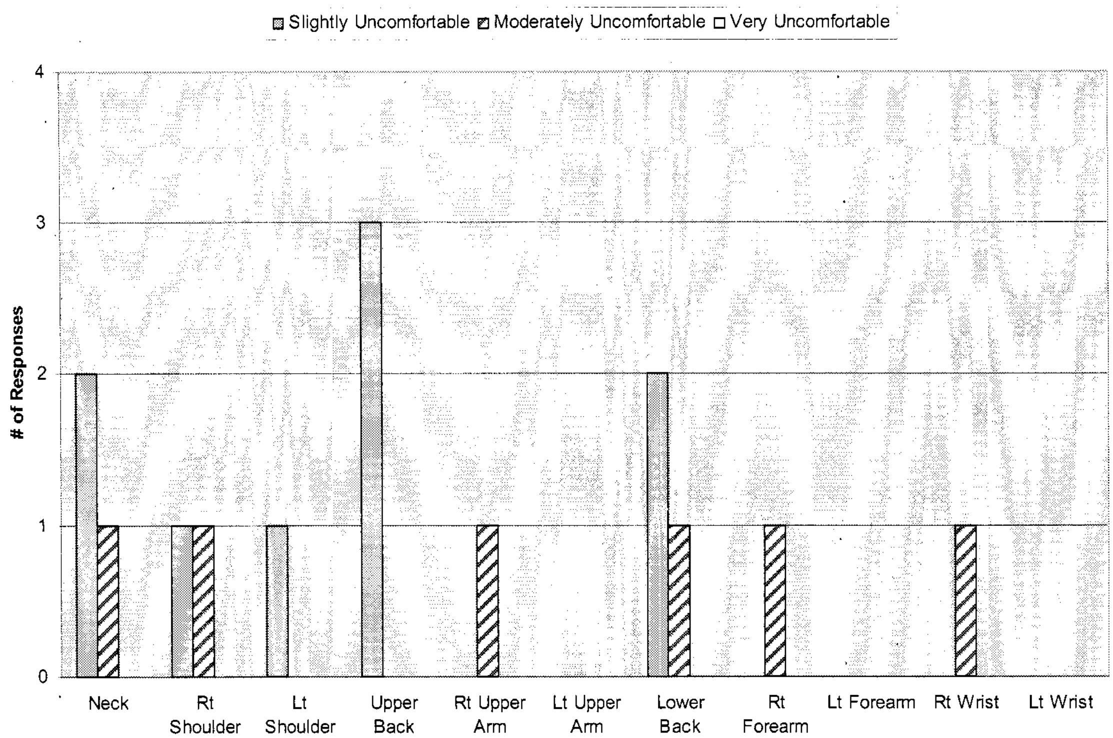


Figure J3. Graph of Trained Group Week 7 Discomfort Levels by Body Part post keyboard tray installation indicating highest frequency of responses in the upper and lower back, and neck; and no very uncomfortable responses.

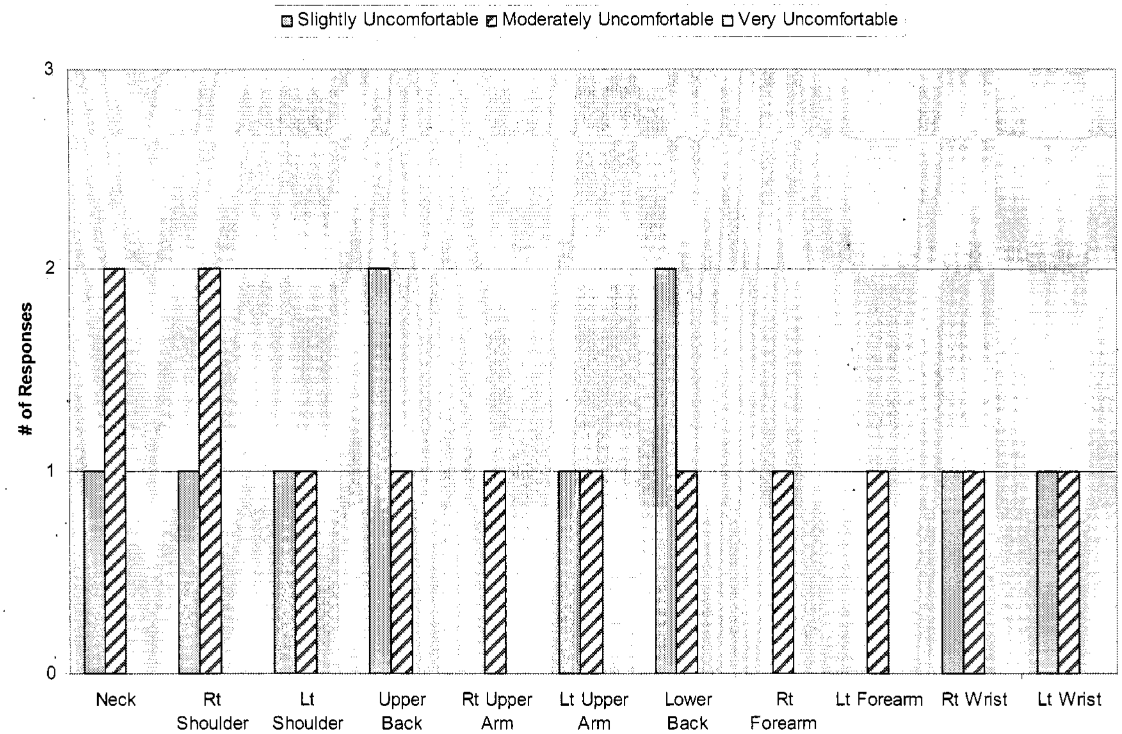


Figure J4. Graph of Untrained Group Week 7 Discomfort Levels by Body Part post keyboard tray installation indicating highest frequency of responses in the upper and lower back, neck, and right shoulder; no very uncomfortable responses.

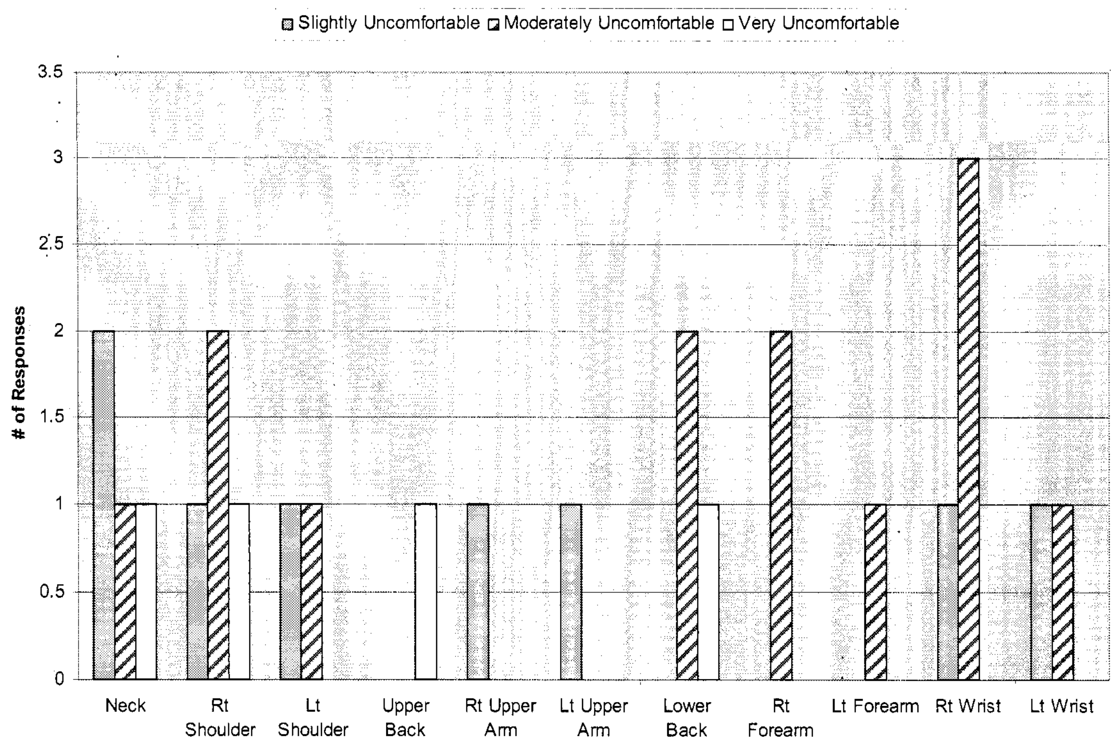


Figure J5. Graph of Trained Group Week 11 Discomfort Levels by Body Part post ergonomic keyboard installation indicating highest frequency of responses in the right wrist; and high severity of responses in the neck, right shoulder and upper arm, and lower back.

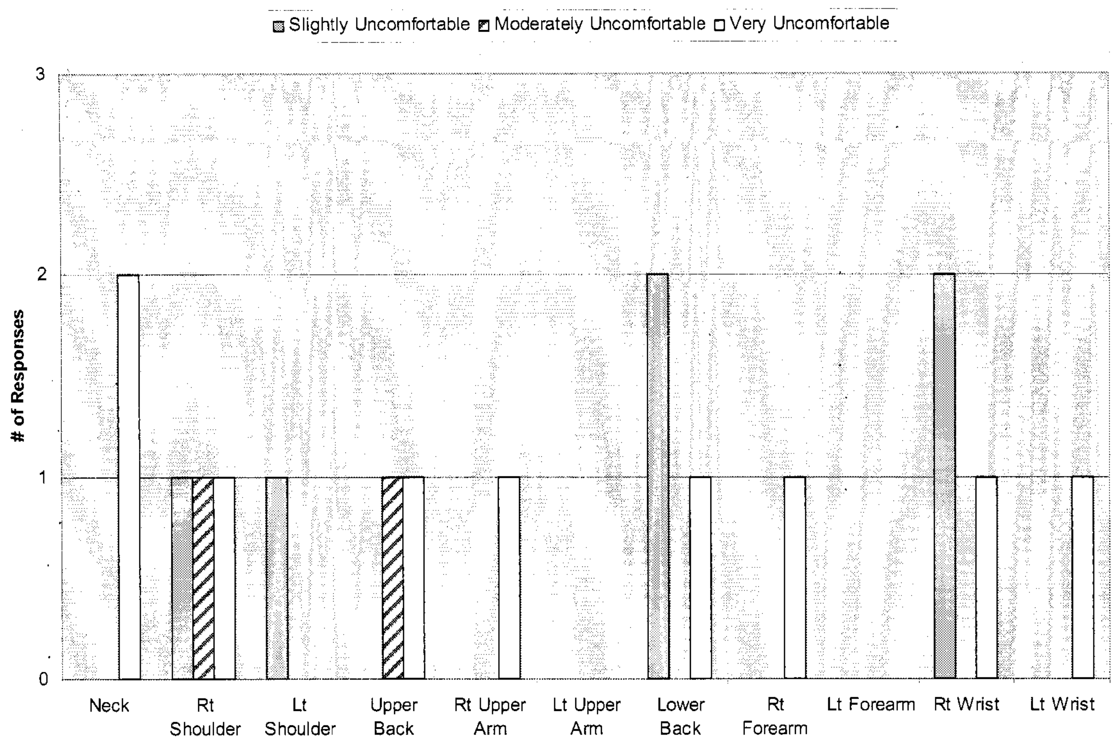


Figure J6. Graph of Untrained Group Week 11 Discomfort Levels by Body Part post ergonomic keyboard installation indicating highest frequency of responses in the lower back and right wrist; and high severity in all body parts except the left shoulder,

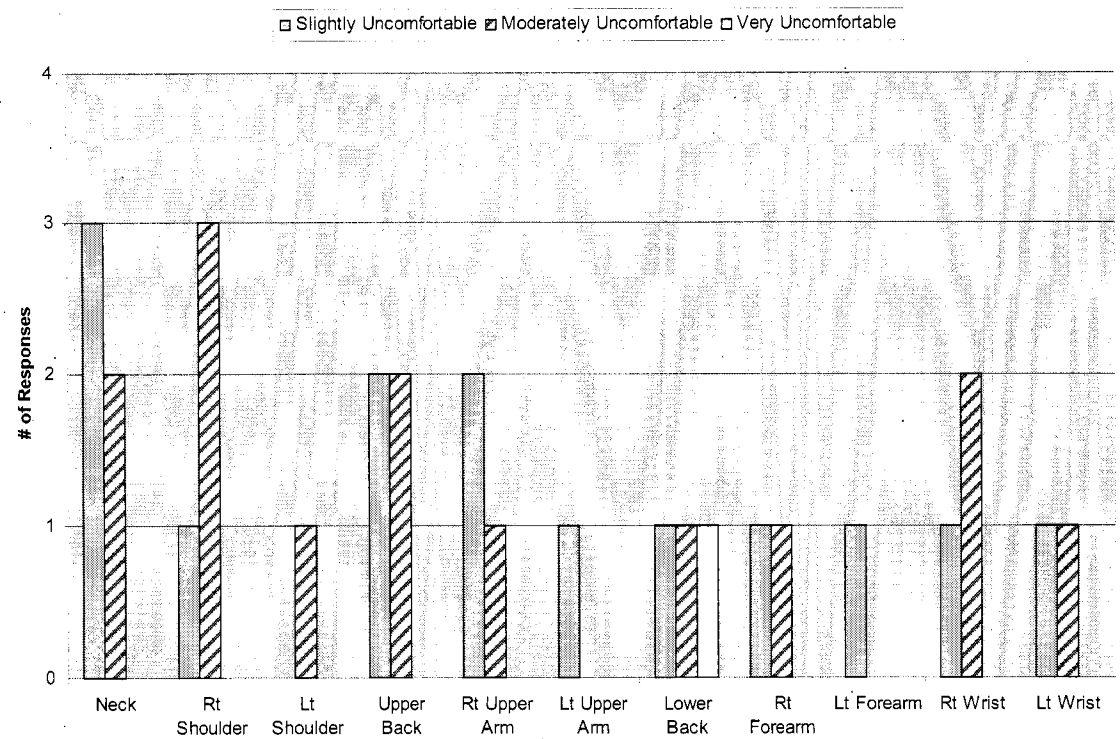


Figure J7. Graph of Trained Group Week 14 Discomfort Levels by Body Part post ergonomic web based training indicating highest frequency of responses in the neck and right shoulder; and highest response severity in the lower back.

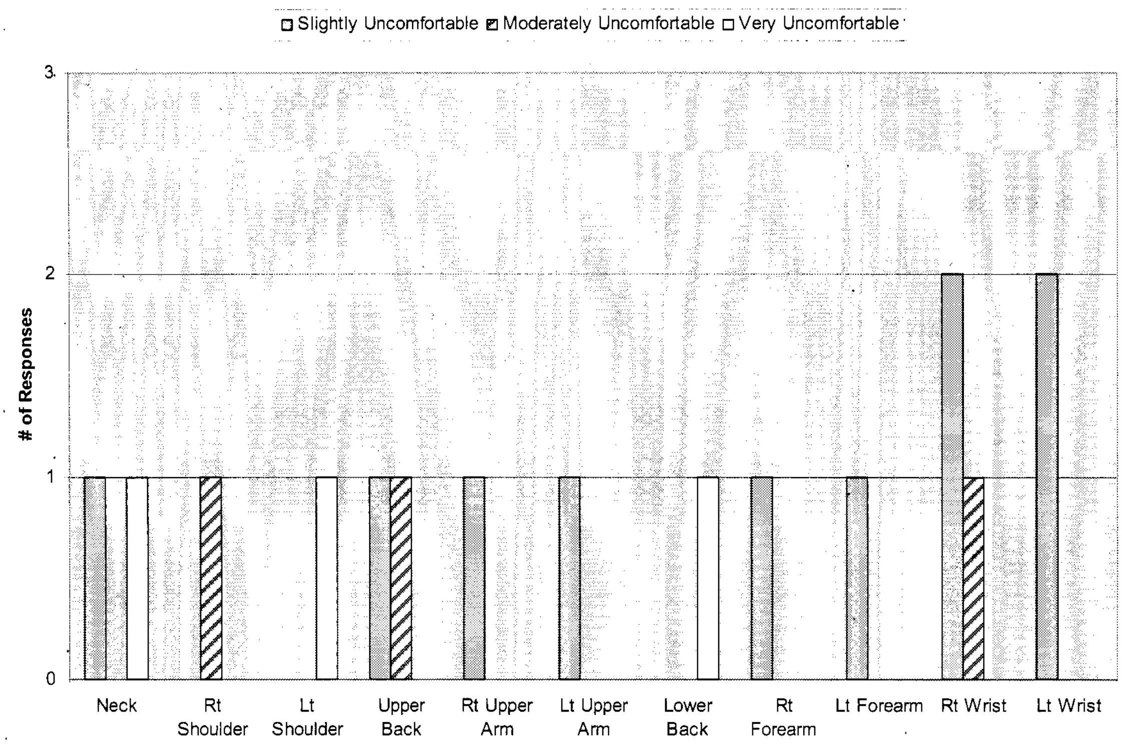


Figure J8. Graph of Untrained Group Week 14 Discomfort Levels by Body Part post ergonomic web based training indicating highest frequency of response in the right and left wrist; and highest severity of response in the neck, and the upper and lower back.

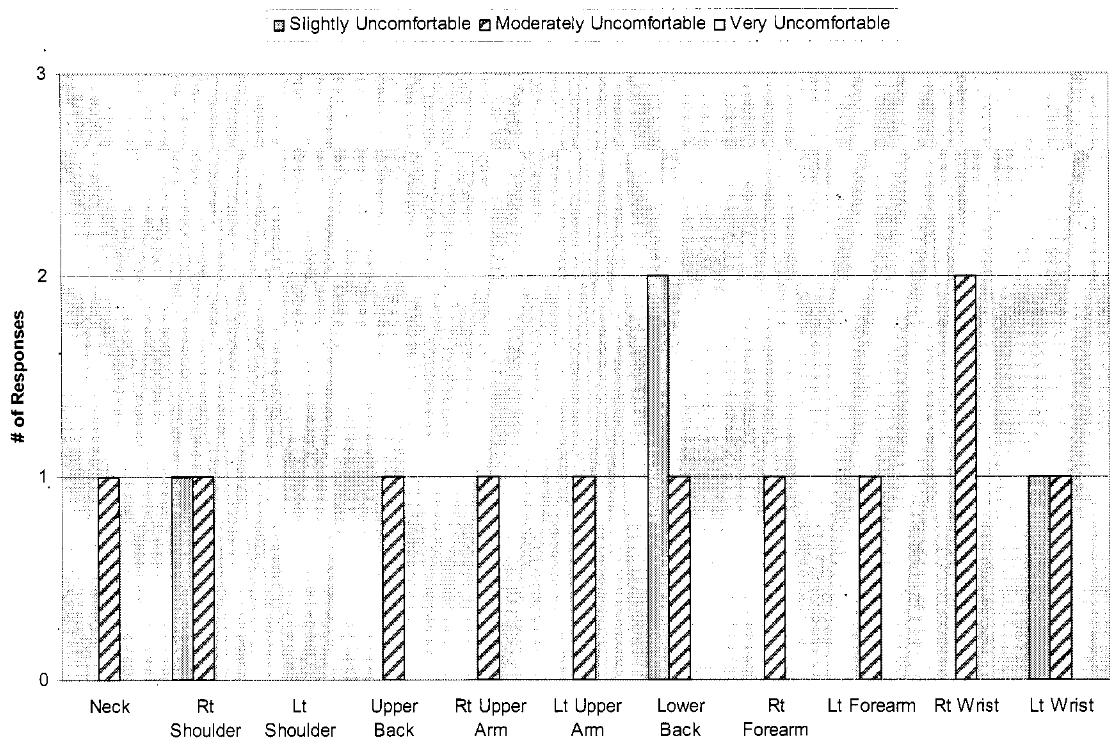


Figure J9. Graph of Trained Group Week 18 Discomfort Levels by Body Part post study complete ergonomic intervention indicating lower frequency of response and severity than all previous graphs.

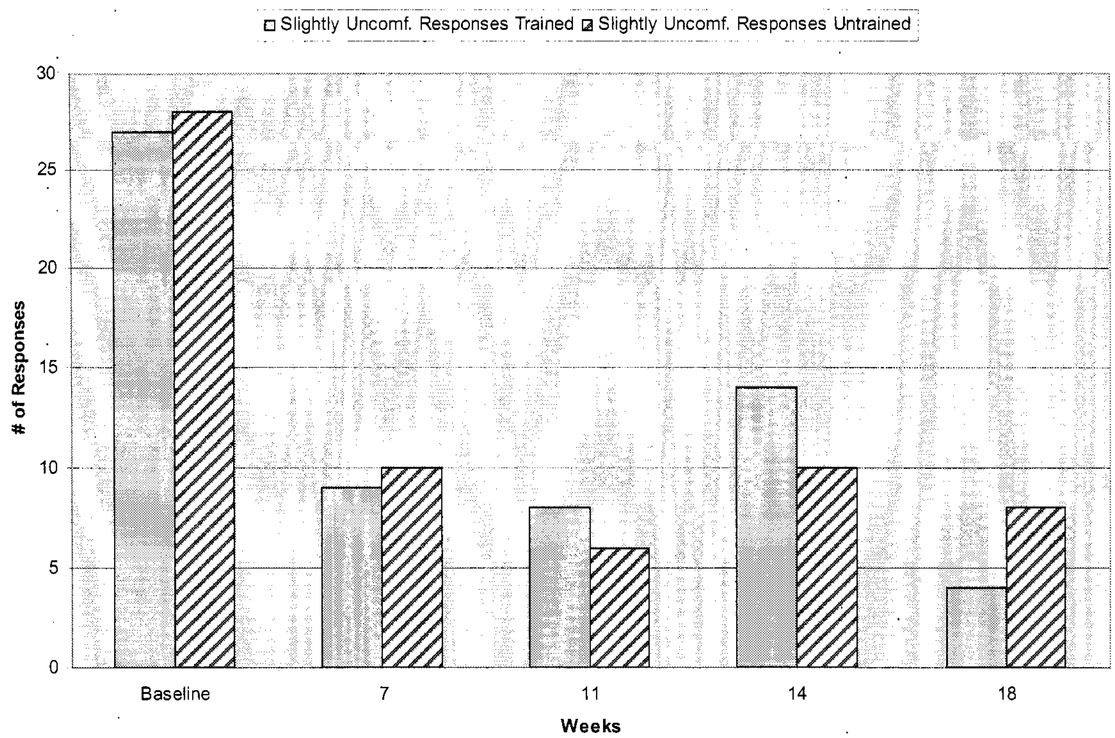


Figure J10. Graph of Untrained Group Week 18 Discomfort Levels by Body Part post study complete ergonomic intervention indicating lowest frequency of response and lower severity levels than all previous graphs.

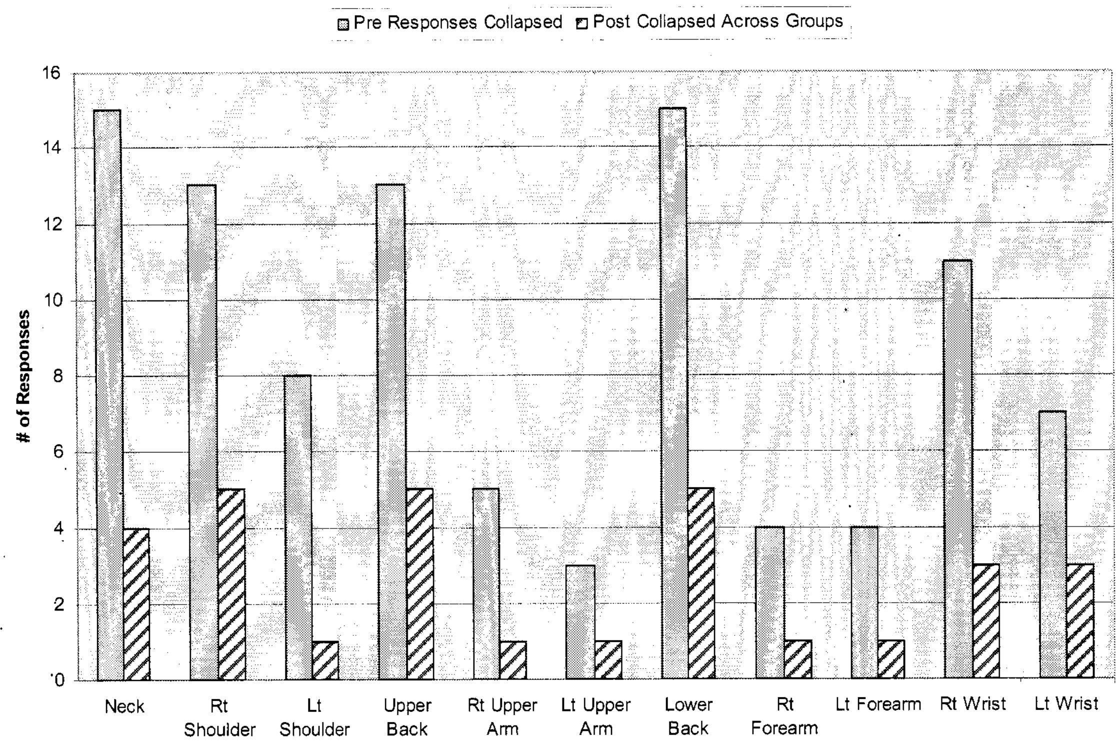


Figure J11. Graph of Pre vs. Post Study Discomfort Levels by Body Part Collapsed Across Trained and Untrained Groups indicating 57-87% frequency of response reduction in each body part and 70% frequency of response reduction overall

APPENDIX K

PERMISSION LETTERS

San José State
UNIVERSITY

Office of the Academic Vice President
Academic Vice President
Graduate Studies and Research

To: Dawn Langer
154 Mohave Terrace
Fremont, CA 94539

From: Nabil Ibrahim, N. I.
AVP, Graduate Studies & Research

Date: December 11, 2002

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

"Effects of Keyboard Experience on Productivity and Comfort."

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to all data that may be collected from the subjects. The approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D. immediately. Injury includes but is not limited to bodily harm, psychological trauma, and release of potentially damaging personal information. This approval for the human subjects portion of your project is in effect for one year, and data collection beyond December 11, 2003 requires an extension request.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services that the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at (408) 924-2480.

Figure K1. San José State University Human Subjects-Institutional Review Board Letter

Environmental and Occupational Risk Management

283 East Java Drive, Sunnyvale, CA 94089-1017 www.eorm.com (800) 648-1506 (408) 822-8100 (408) 822-8001 (FAX)

November 7, 2002

San Jose State University
Human Subjects Institutional Review Board
Walquist Library North, Room 125
San Jose, CA 95192-0025

Attn: HSIRB Coordinator

To whom it may concern:

This letter is to give express permission for Dawn Langer to use one Environmental and Occupational Risk Management, Inc. (EORM) photos (See Appendices H, Figures H4) in her San Jose State University Master's Thesis proposal, and in any publishable documents that result thereof

Ms Langer's human factors/ergonomics study is entitled Effects of Keyboard Experience on productivity and Comfort. EORM is aware that the study will run for a period of 120 days beginning in December 2002, or January 2003. There are no employee health risks associated with this study.

During that time, Ms. Langer will recruit America Online, Inc. subjects via email, fliers and word of mouth, brief subjects at a kickoff meeting, ergonomically adjust individual workstations and install productivity software on participant computers. After the study is complete Ms. Langer will collect online productivity data, debrief participants and publish study in a professional ergonomics journal.

Sincerely,

Glenn Fishler, President
EORM, Inc.

Theresa Quigley, Sunnyvale Operations Mgr
EORM, Inc.

Figure K2. Environmental Occupational Risk Management Letter

AMERICA ONLINE

INCORPORATED

November 4th, 2002

San Jose State University
Human Subjects Institutional Review Board
Walquist Library North, Room 125
San Jose, CA 95192-0025

Attn: HSIRB Coordinator

To whom it may concern:

This letter is to give express permission for Dawn Langer to use two America Online, INC. (AOL) photos (See Appendices H, Figures H1 and H5 of thesis proposal, and recruit AOL employees as subjects for the human factors/ergonomics study entitled Effects of Keyboard Experience on Productivity and Comfort.

Dawn Langer has been an employee of AOL since March 5th, 2001, and has been attending San Jose State University throughout that time period. The study will run for a period of 120 days beginning in December 2002, or January 2003. There are no employee health risks associated with this study

During that time, Ms. Langer will recruit subjects via email, fliers and word of mouth, brief subjects at a kickoff meeting, ergonomically adjust individual workstations and install productivity software on participant computers. After the study is complete Ms. Langer will collect online productivity data, debrief participants and publish study in a professional ergonomics journal

Sincerely,

Kevin Donohoe, Facilities Director

Nancy Perkins

Nancy Perkins, Directory Risk Management

22000 AOL Way • Dulles, Virginia [illegible] • 703/448-8700
[illegible]

Figure K3. America Online, Inc. Letter

Department of Design &
Environmental Analysis

Cornell University
Martha Van Rensselaer Hall
Ithaca, NY 14853-4401

Telephone: 607 255-1957
Fax: 607 255-0305
E-mail: ah29@cornell.edu
Web: ergo.human.cornell.edu

College of Human Ecology

November 25th, 2005

San Jose State University
Human Subjects Institutional Review Board
Walquist Library North, Room 125
San Jose, CA 95129-0025

Attn: HSIRB Coordinator

To whom it may concern:

This letter is to give express permission for Dawn Langer to customize and use the pre study evaluation and weekly evaluation forms provided (see Appendices E and G) in her ergonomic study entitled: Effects of Intervention and Training on Productivity and Comfort (aka: Effects of Keyboard Experience and Training on Productivity and Comfort).

Sincerely,

AHedge

Professor Alan Hedge, PhD, CPE, FHES, FErgS, AFBPsS

Figure K4. Dr. Alan Hedge, Letter

San José State
UNIVERSITY

Office of the Provost
Associate Vice President
Graduate Studies & Research

One Washington Square
San José, CA 95192-0025
Voice: 408-924-2427
Fax: 408-924-2477

E-mail: gradstudies@sjsu.edu
http://www.sjsu.edu

To: Dawn Langer
154 Mohave Terrace
Fremont, CA 94539

From: Nabil Ibrahim N. Ibrahim
AVP, Graduate Studies & Research

Date: March 3, 2003

This letter acknowledges that the Human Subjects-Institutional Review Board has received the request for extension of the following study:

"Effects of Keyboard Experience on Productivity and Comfort"

Since there are no major changes to the protocol, the Human Subjects-Institutional Review Board has granted this project a one-year extension effective from the date of this letter. Data collection beyond March 3, 2004 requires an extension request.

If you have any questions, please do not hesitate to contact me at (408) 924-2480.

Figure K5. San José State University Human Subjects-Institutional Review Extension